REMOTE HANDLING AT LAMPF/LANSCE

Los Alamos National Laboratory

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LANSCE-7 Group Leader

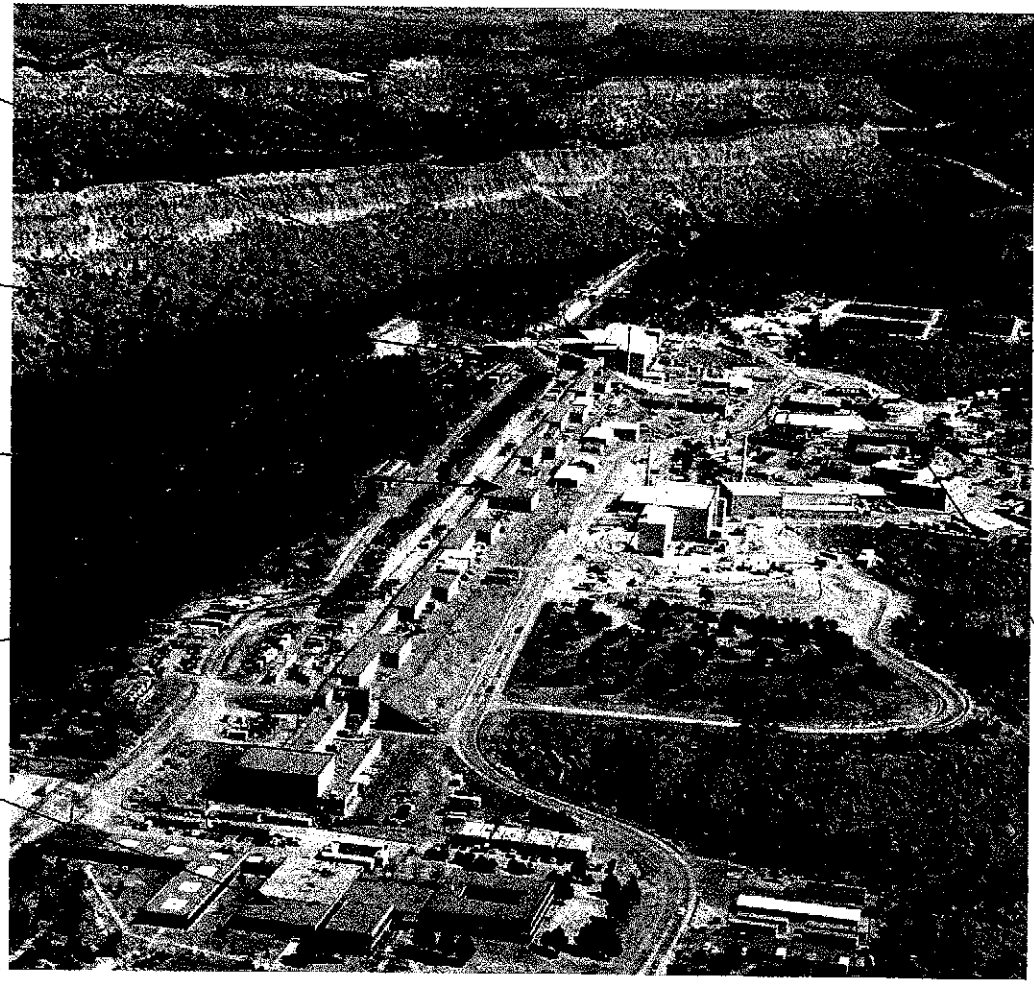
High Intensity Beam Lines, Experimental Areas, and Remote Handling

REMOTE HANDLING AT LAMPF/LANSCE

- Why remote handling?
- Remote handling methods.
- Remote handling evolution at LAMPF/LANSCE.
- LAMPF/LANSCE remote handling hardware/capabilities.
- General remote handling considerations:
  - Remote handling operations
  - Beam line design
    - Components
    - Access
    - Other

NOTE: This is a compilation of 30 years of sometimes painful experience at LAMPF/LANSCE.

The Los Alamos Neutron Science Center



WHY REMOTE HANDLING AT LAMPF/LANSCE?

- **Conditions leading to the need for remote handling:**
  - High power beam: 1mA @ 800 MeV
    - * 800 kWatt
  - High residual radioactivity resulting from beam interactions.
    - * > 10^5 rad/hr

- **Activities requiring remote handling:**
  - *In situ* maintenance/testing of components.
  - Removal/Disassembly of irradiated components.
  - Installation/Hookup/Alignment of components in highly radioactive areas.
  - Post irradiation inspection of components.

NOTE: Conditions that lead to the need for remote handling also result in design criteria for beam line components.

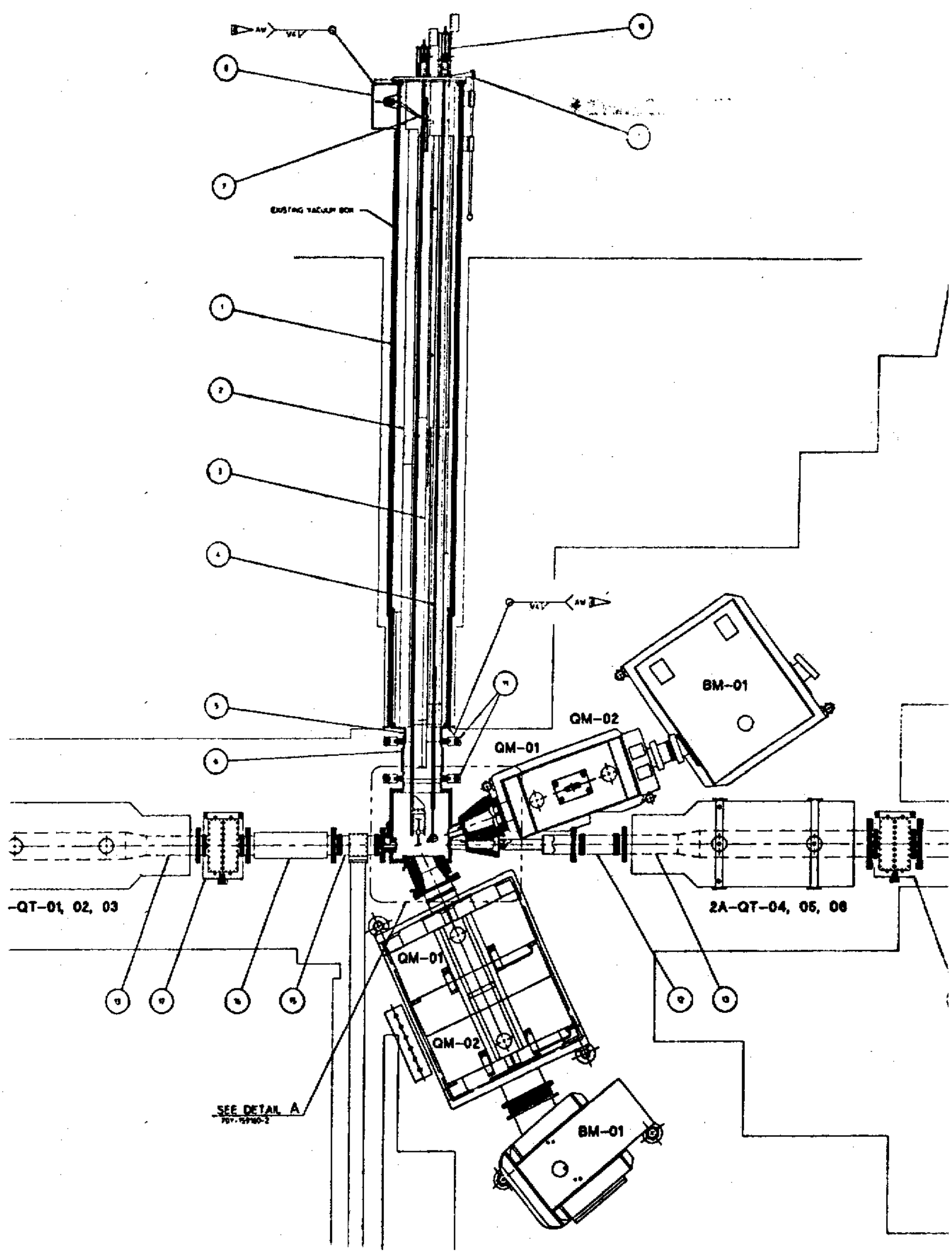
REMOTE HANDLING METHODS

- Task specific - limited number of well-defined tasks in localized area.
  - Limited access to components
  - Restricted motion
  - Designed for specific operations
  - Specialized tooling often required

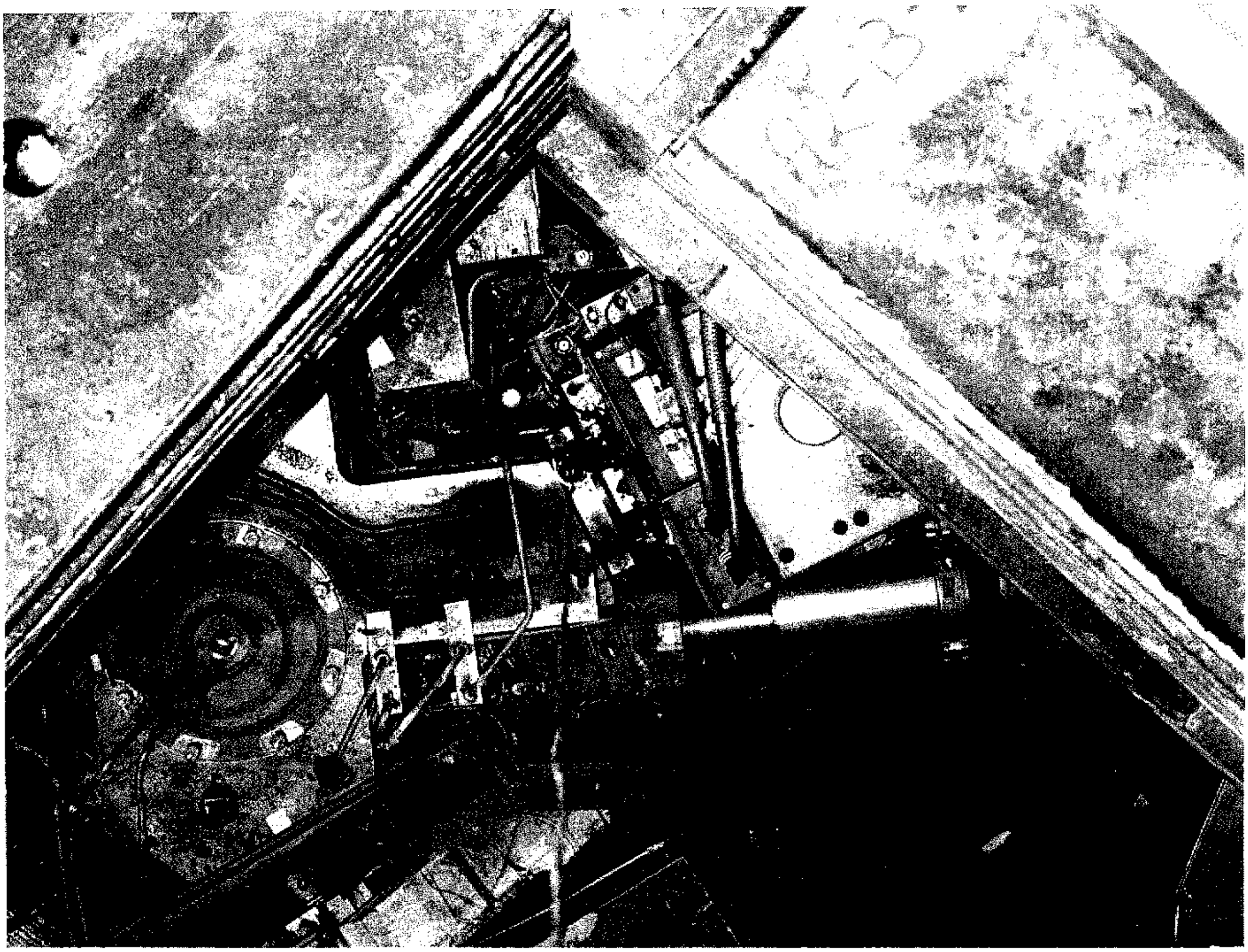
- General purpose - large number of ill-defined tasks in various locations.
  - "Free" access to components
  - Highly maneuverable
  - Capable of various operations
  - "Off-the-shelf" tools/components can generally be used

REMOTE HANDLING EVOLUTION AT LAMPF/LANSCE

- Original designers of LAMPF recognized that remote handling would be necessary.
- Early-1970's: Task specific - "Merrimac"
  - Moving hot cell.
  - Result:
    * Proved to be impractical even before beam delivery began <u>but not early enough.</u>
    * Had far-reaching, long-term effects on component/shielding designs.
- Mid-1970's: General purpose - "Monitor"
  - Conceptual design - R. Horne, CERN
  - Implementation - D. Grisham, J. Lambert, et al, LAMPF
  - Features:
    * Portable system.
    * Highly maneuverable/dextrous operations possible at the worksite.
    * Force-reflection on manipulators.
    * High visibility at worksite using closed circuit TV.
    * Control possible from a distance - ALARA.
- Mid-1980's: General purpose - "Monitor" adaptations


EXISTING VACUUM BOX
QM-02
QM-01
BM-01
-QT-01, 02, 03
2A-QT-04, 05, 06
QM-01
QM-02
SEE DETAIL A
BM-01

AREA A TARGET STATION A-2



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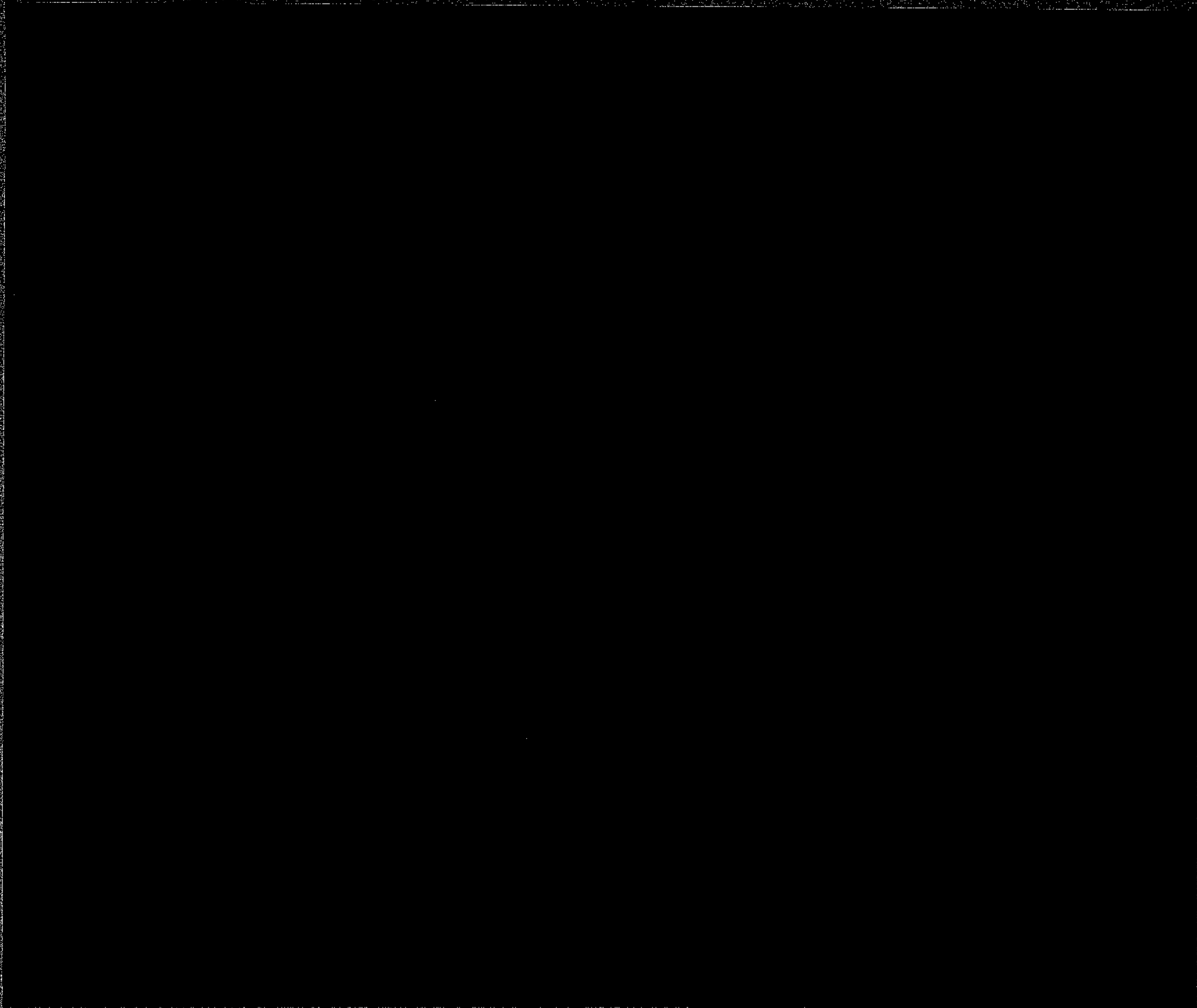
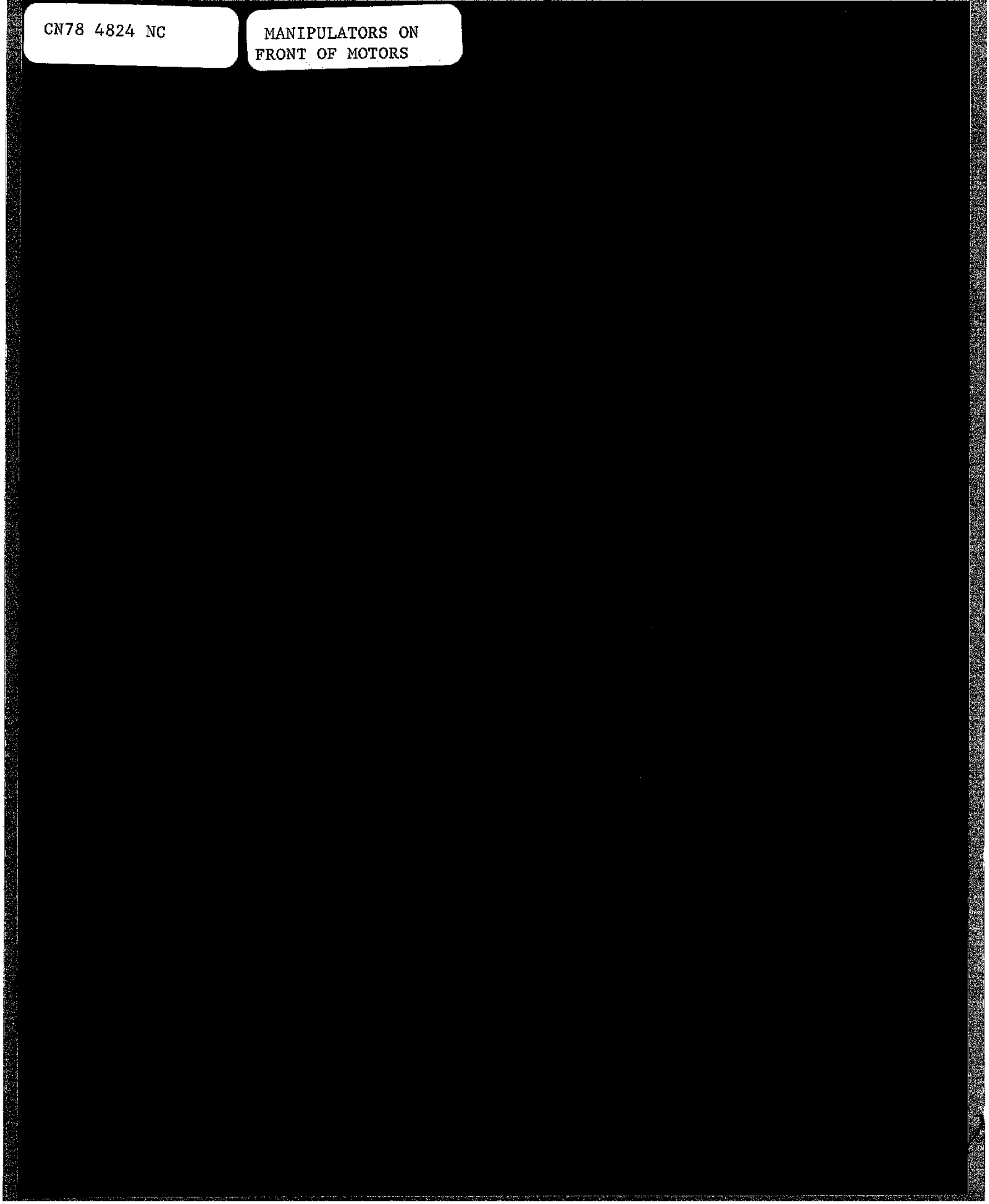
MONITOR HARDWARE

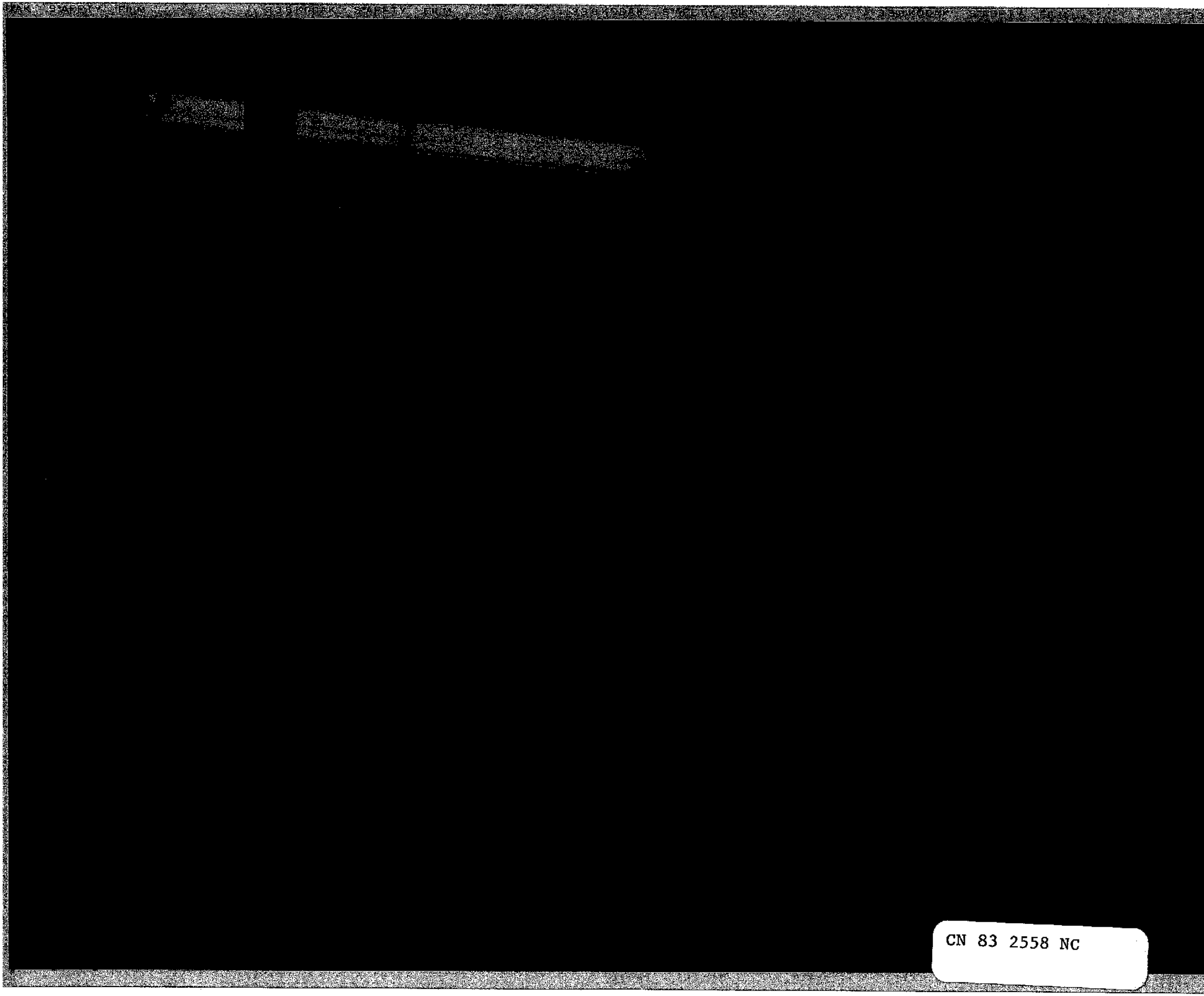
- Original:
  - Remotely operated:
    * Electric, force-reflecting, master-slave servo-manipulators
    * Hydraulic boom to support manipulators - articulating, telescoping
    * Closed-circuit television viewing with:
      - Multiple TV cameras/monitors
      - Pan/Tilt/Zoom
      - One camera on a separate actuator
    * Separate 30 ton overhead crane
  - Master control trailer
- Improvements/Adaptations:
  - Color TV cameras/monitors
  - Mobile master control station
  - Digital electronics (programmable) - *now obsolete*
  - Ability to mount manipulators on different support platforms at the worksite

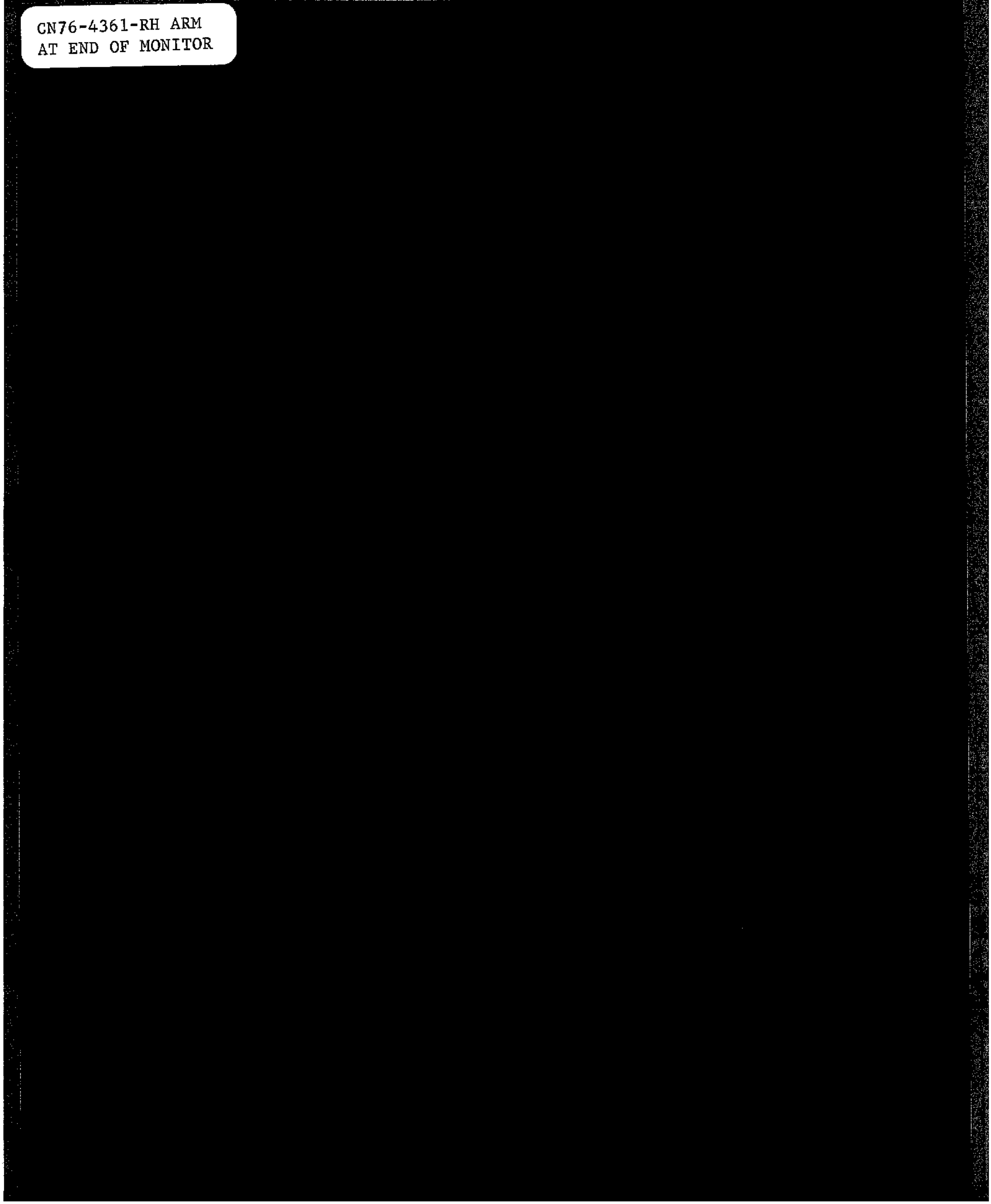


CN78 4824 NC

MANIPULATORS ON
FRONT OF MOTORS




CN 83 2558 NC



CN76-4361-RH ARM
AT END OF MONITOR

MONITOR CAPABILITIES

- Up to two manipulators per boom
- 22 pound capacity per manipulator
- Standard operations that can be performed:
  - Soldering/Welding
  - Cutting/Burning - torches
  - Bolting/Rigging - eye bolts, shackles
  - Drilling/Tapping
  - Grinding/Sawing
  - Painting - spray, brush
  - etc.

REMOTE HANDLING CONSIDERATIONS - OPERATIONS

- Number of operating personnel required: 2 to 4, or more depending on operation
- Duration of individual operations: $\geq$ 4 to 10, or more times longer than by hand depending on operation
- Time/Resources to prepare - set up, mock ups, dry runs
- Cost of equipment - "several" million dollars
- Reliability of equipment - check-outs, inspections
- Access/Viewing required
- Special tooling required
- ALARA/Contamination control - including shielded casks
- Industrial safety - falls, trips, manipulators, etc.
- Ergonomics
- Consequences of mistakes - <u>A HUGE FACTOR</u>
  - Need to exercise *extreme* care

REMOTE HANDLING CONSIDERATIONS - DESIGN

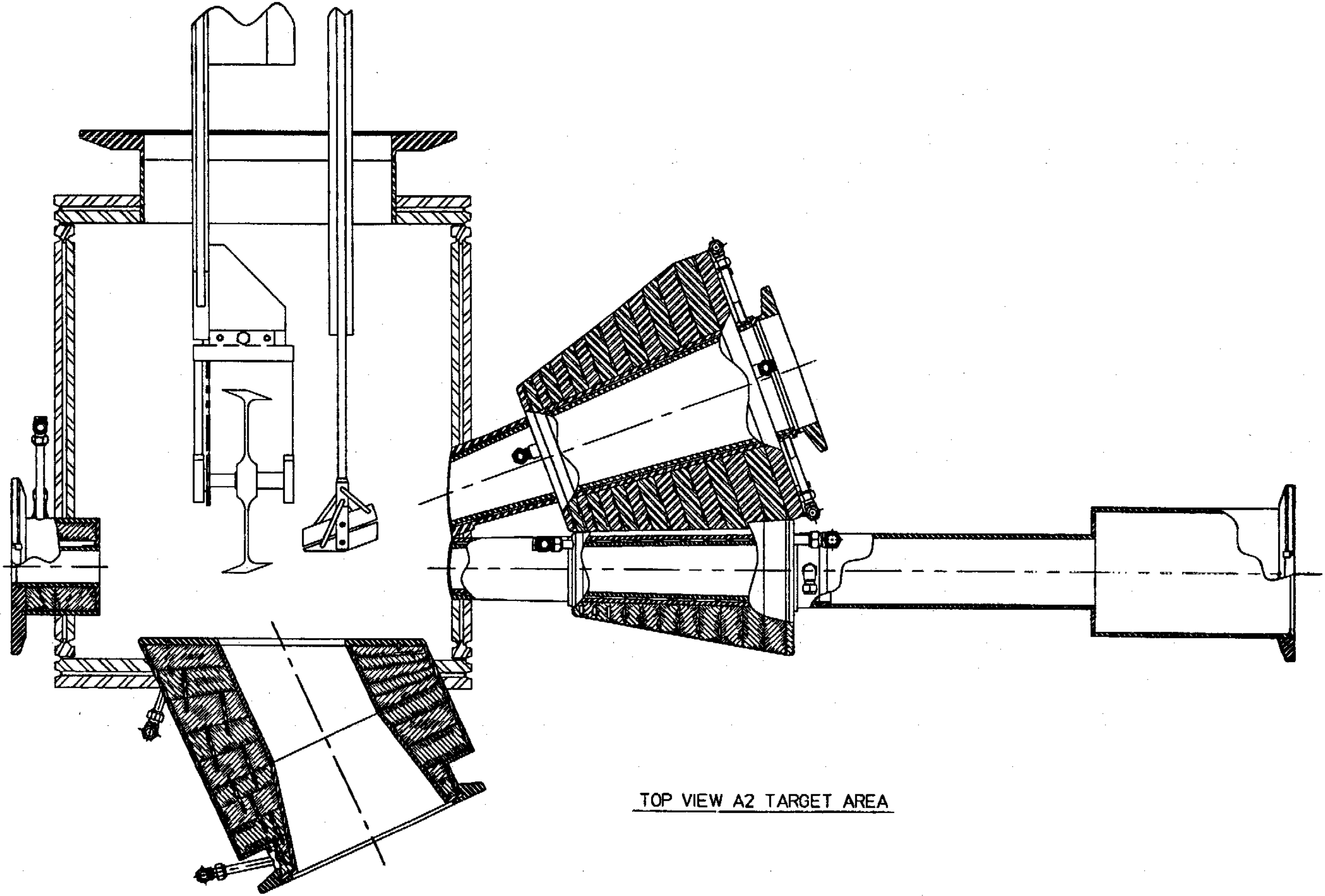
- Components in high radiation/heat environment:
  - Fundamental understanding and sound engineering required for "everything."
  - Heavily overdesign; consider static and cyclic stresses.
  - Cool to minimize amplitude of beam on/off temperature cycles.
  - Consider radiation damage effects; mainly material embrittlement.
  - Simpler is better for reliability and maintainability; don't get "clever."
  - Minimize connections - electrical, water, vacuum.
  - Minimize movable and electrical devices (including diagnostics).
  - Locate required connections and "vulnerable" devices as far from primary radiation/heat source as possible.
  - Use inorganics; avoid elastomers and other organics if possible.
  - Use stainless steel and inconel; avoid brass and copper if possible.
  - Design components to be remotely diagnosed/maintained/replaced.
  - Design for worst case and upset beam conditions.
  - Design with component alignment in mind.

REMOTE HANDLING CONSIDERATIONS – DESIGN *(cont'd)*

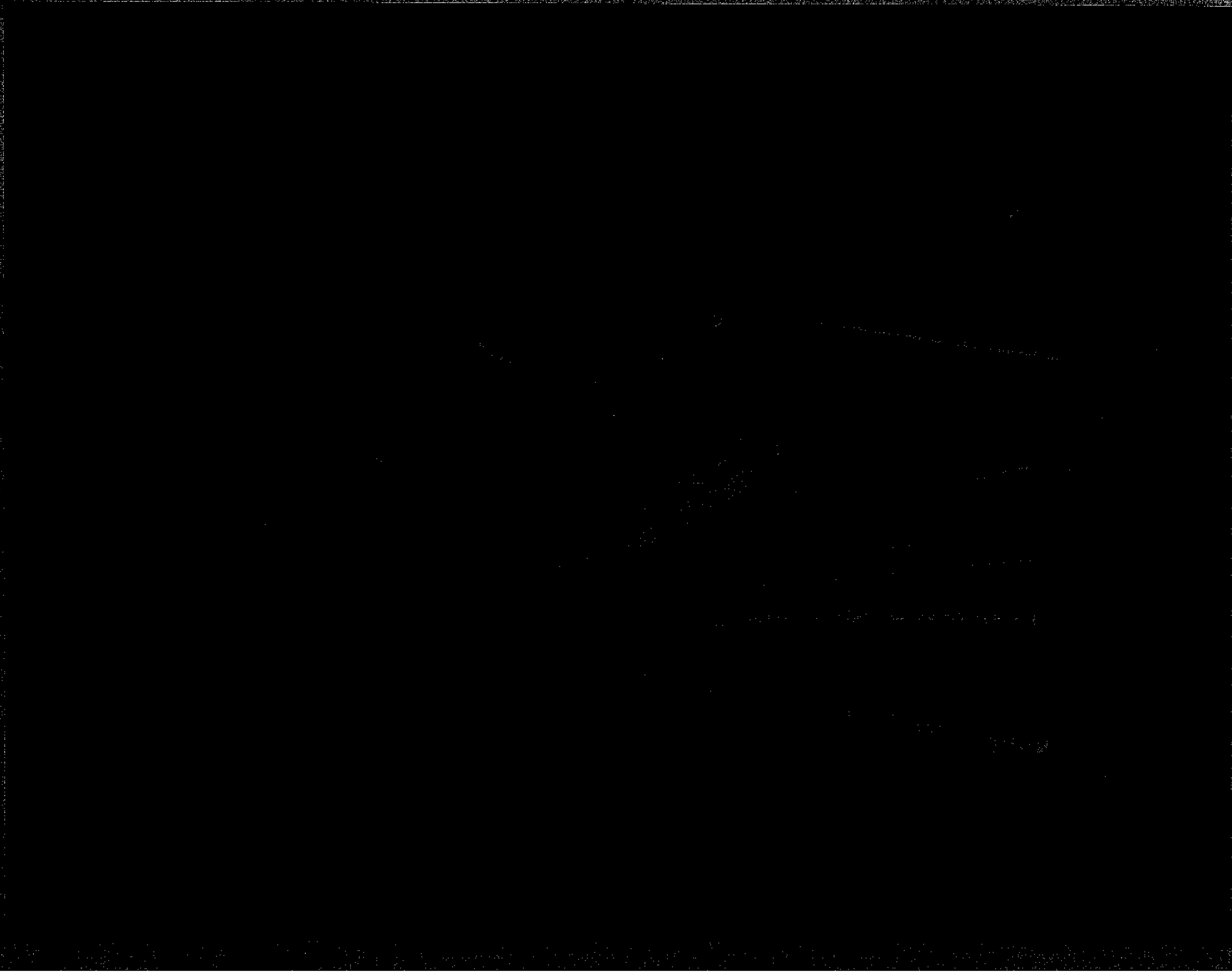
- **Access to components in high radiation environment:**
  - Consider access from the beginning of design.
  - Assume components will need to be accessed.
    * Space around components for work and viewing.
    * Crane access and hookups; "fine" crane control required.
  - Layout of service penetrations through shielding very important.
  - Design connections as simple and as rugged as possible; overdesign.
  - Provide locating devices for component placement/removal; guide pins, locating blocks, etc.
  - Lift large pieces of shielding to reach components; minimize large movable shield "doors" near highly radioactive components.
  - Shielded vertical penetrations preferred.
    * Components on bottom.
    * Services/Connections on top.

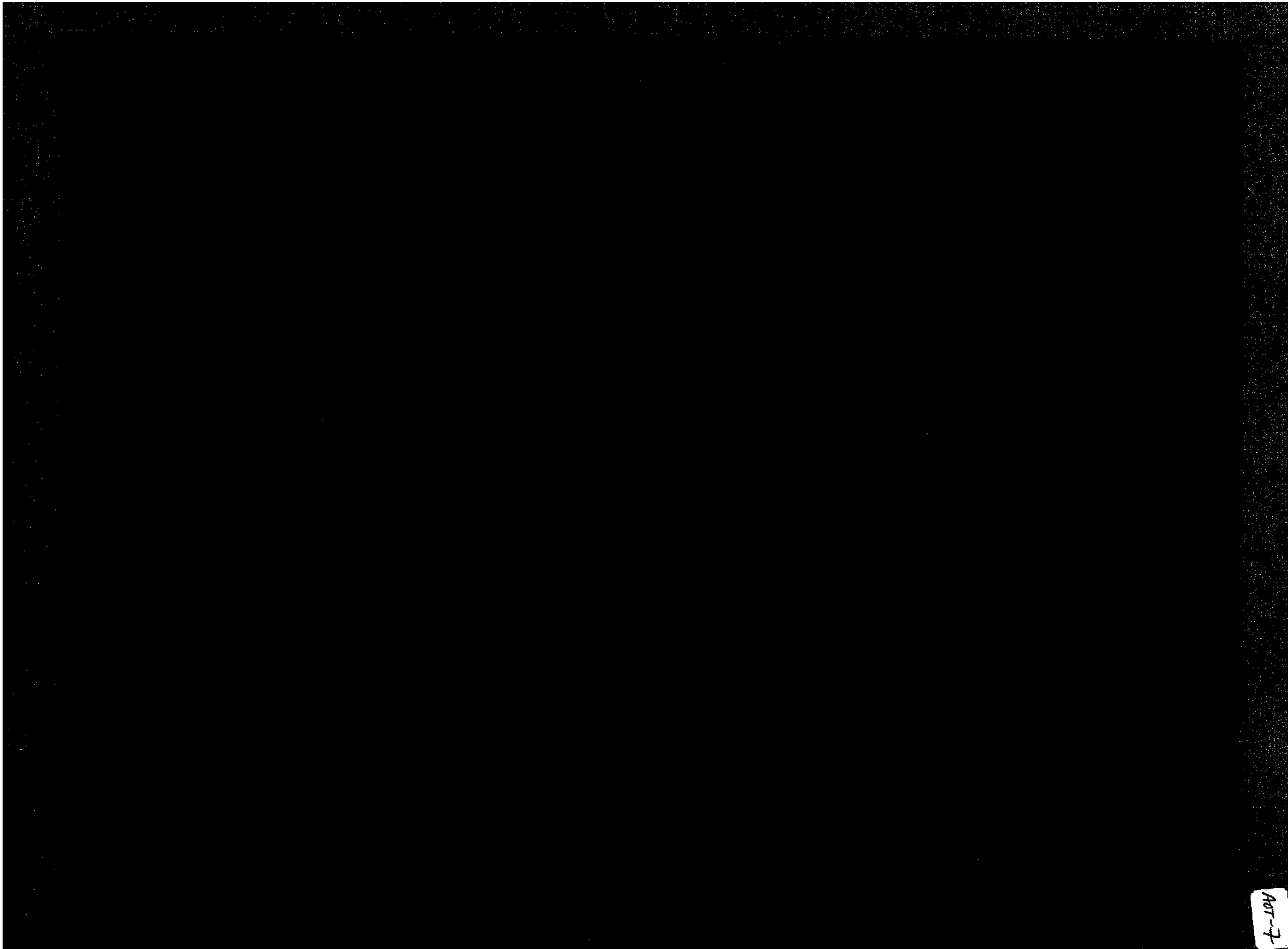
REMOTE HANDLING CONSIDERATIONS – DESIGN *(cont'd)*

- Other:
  - Alignment schemes; LANSCE has used:
    - 3-D triangulation as primary method.
      - Good to ~ 0.5 mm in the field.
      - e.g., ManCAT System by Leica.
    - Laser ranging for "rough" work.
      - Good to ~ 2 mm in the field.
      - e.g., Total Station System by Pentax.
    - Bore-sighting for sanity check.
  - Radioactive air in high intensity beam interaction areas.
    - Emissions during beam delivery - mostly ^{11}C, ^{13}N, ^{15}O, ^{41}Ar.
    - Generation of nitric acid, ozone, etc. results in corrosion.
    - Minimize emissions by containment and delaying radioactive air before release.
  - Radioactivity in closed-loop cooling water systems.
    - Produced during beam delivery - mostly ^{3}H, ^{7}Be, spallation and erosion products.
    - Generation of hydrogen peroxide results in material corrosion.
    - Water/Material interfaces through which beam passes exhibit corrosion and deposits from "stuff" in water.
    - Minimize water effects on materials by maintaining a "clean" water system that does not degrade protective oxide layers – use filters, resin beds, etc.
    - Build containment for spilled water.

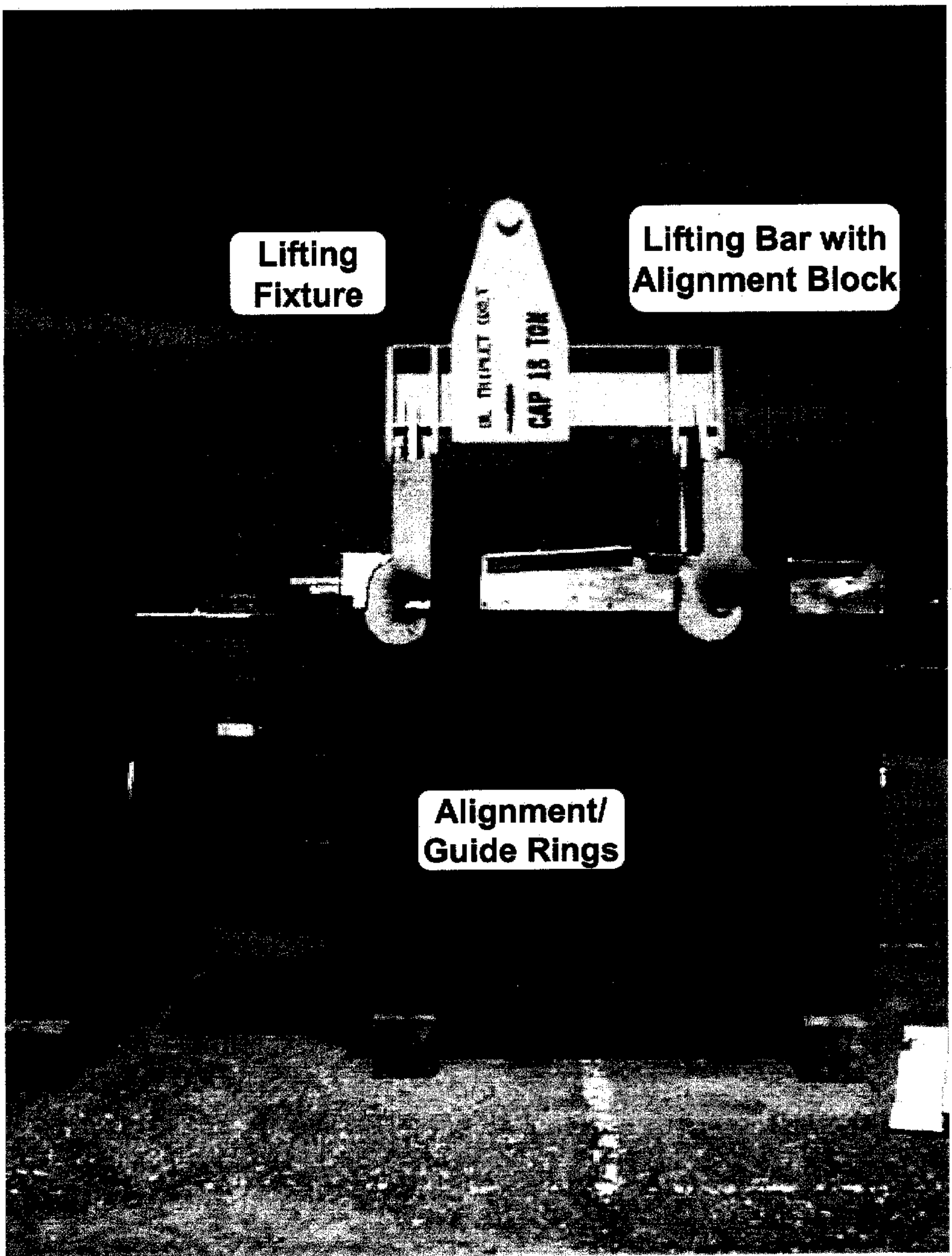


TOP VIEW A2 TARGET AREA

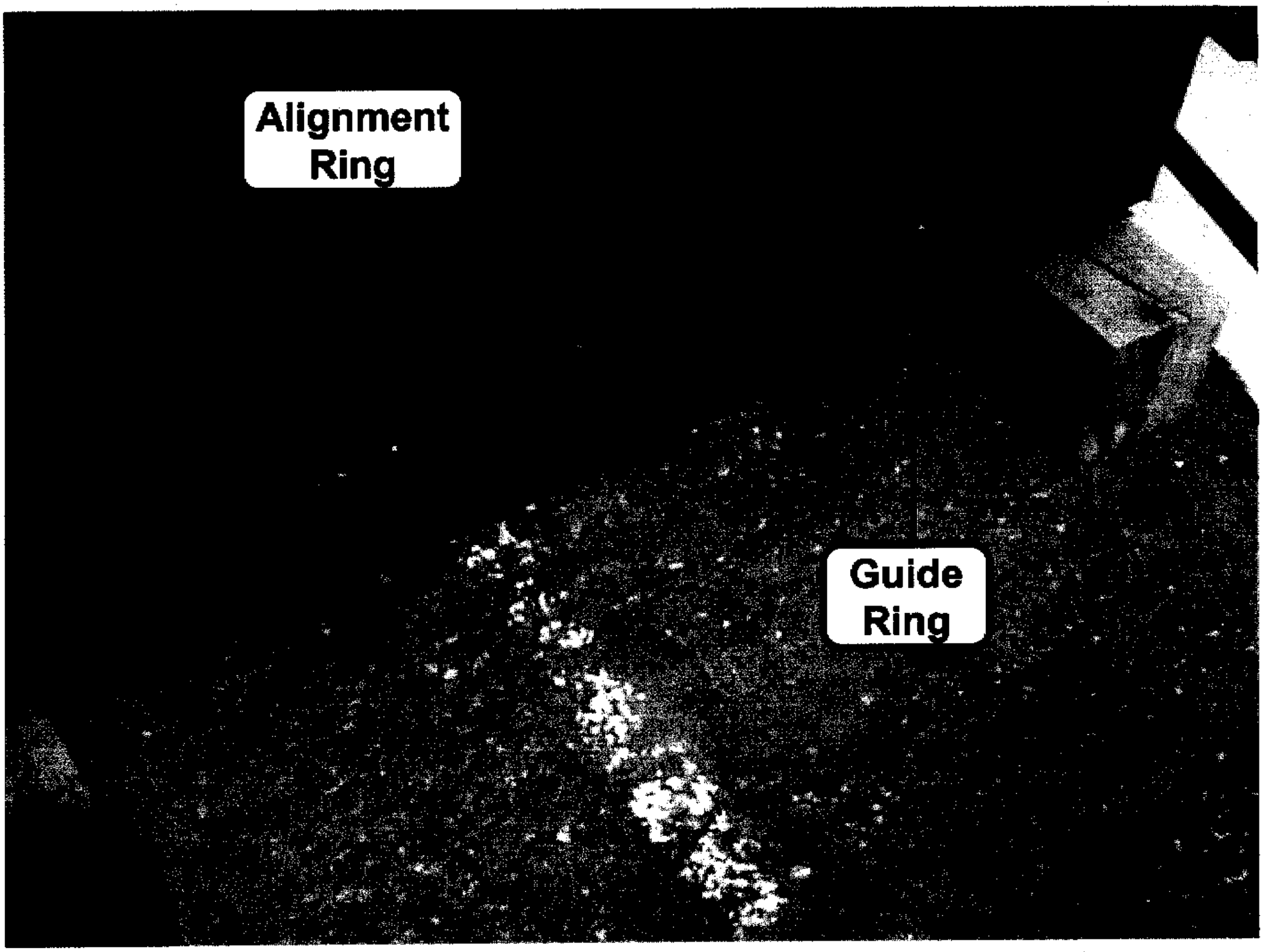



AOT-7

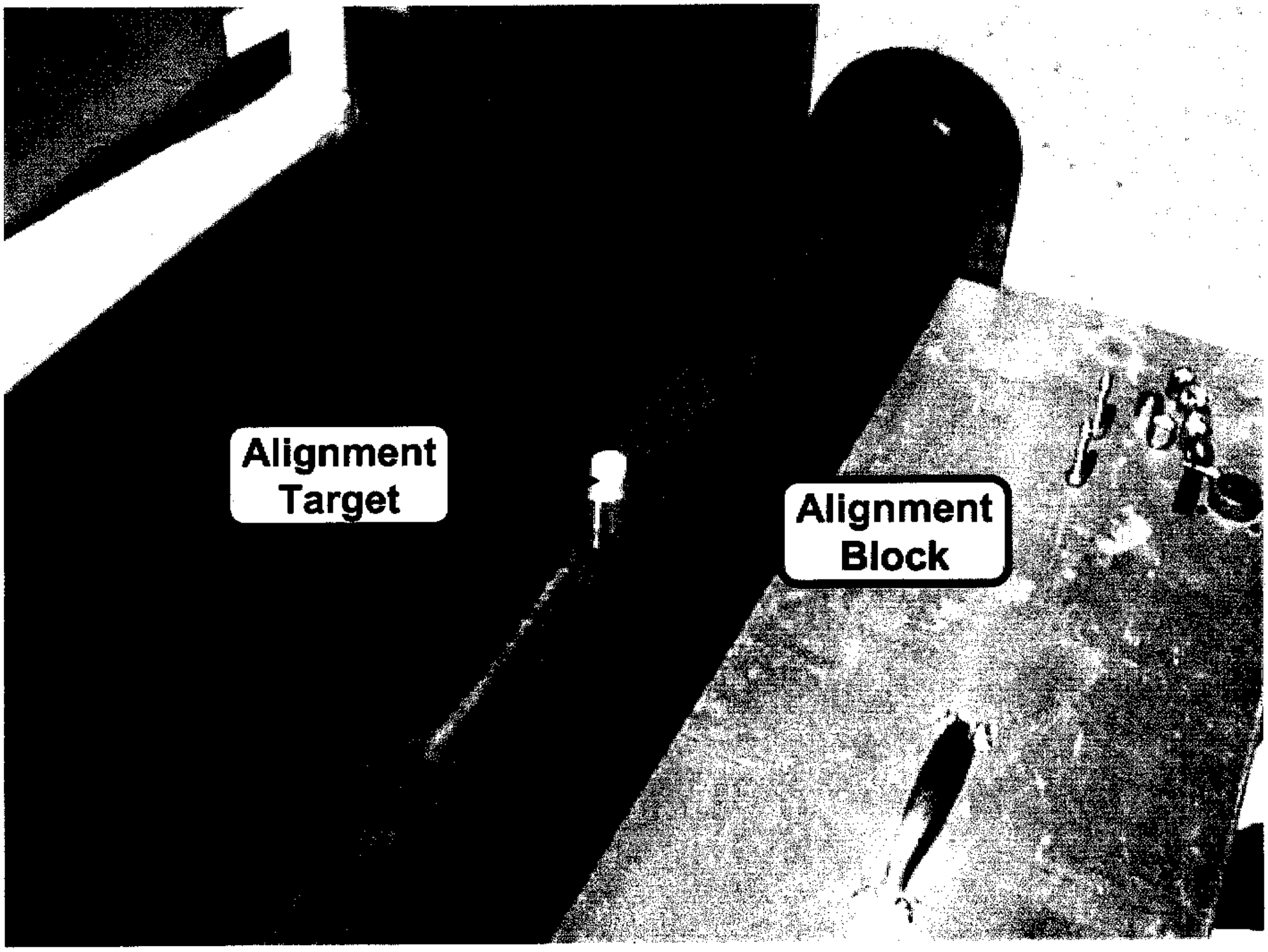
Area A Target Cell Quadrapole Triplet



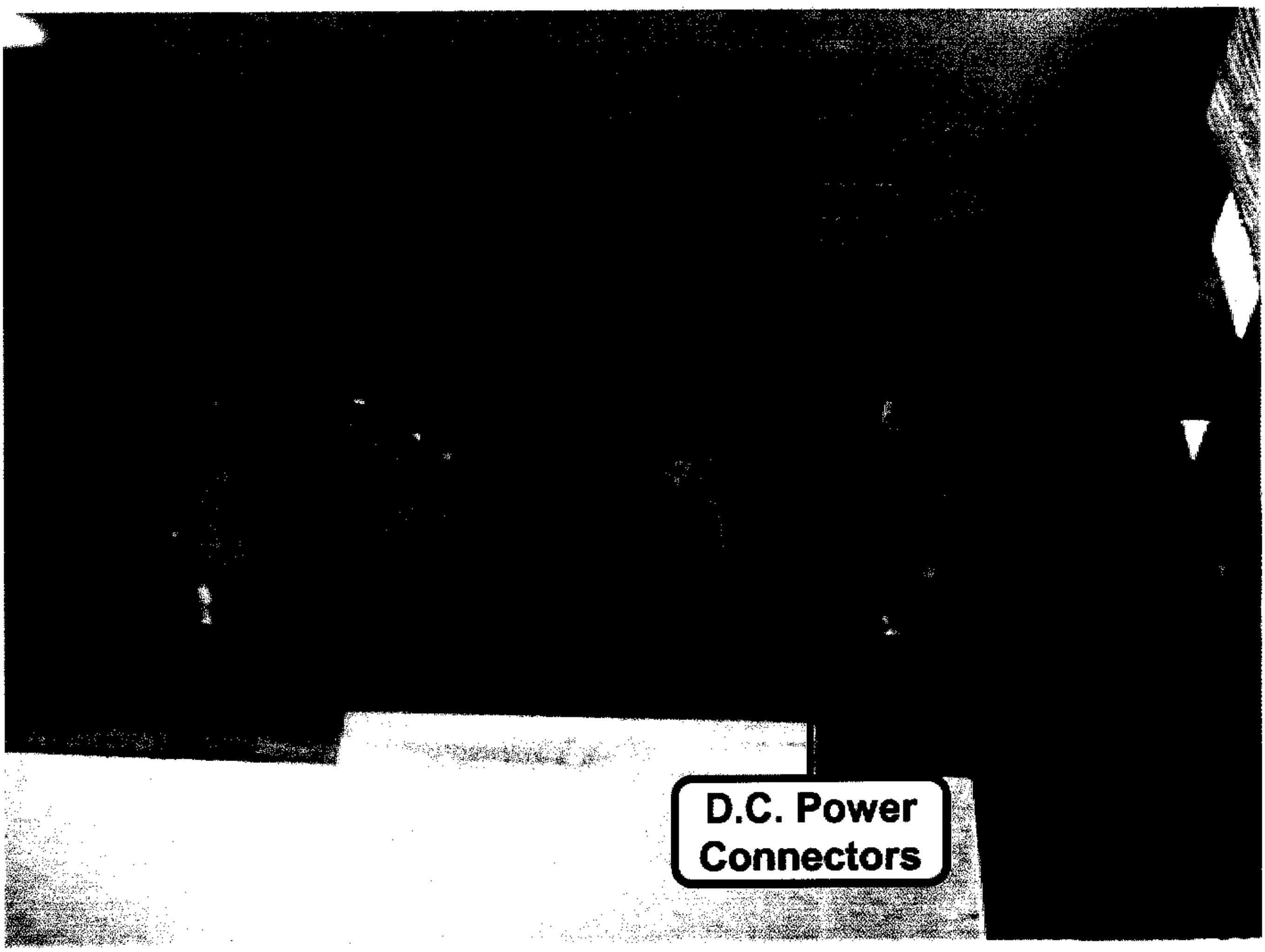
Area A Target Cell Quadrapole Triplet



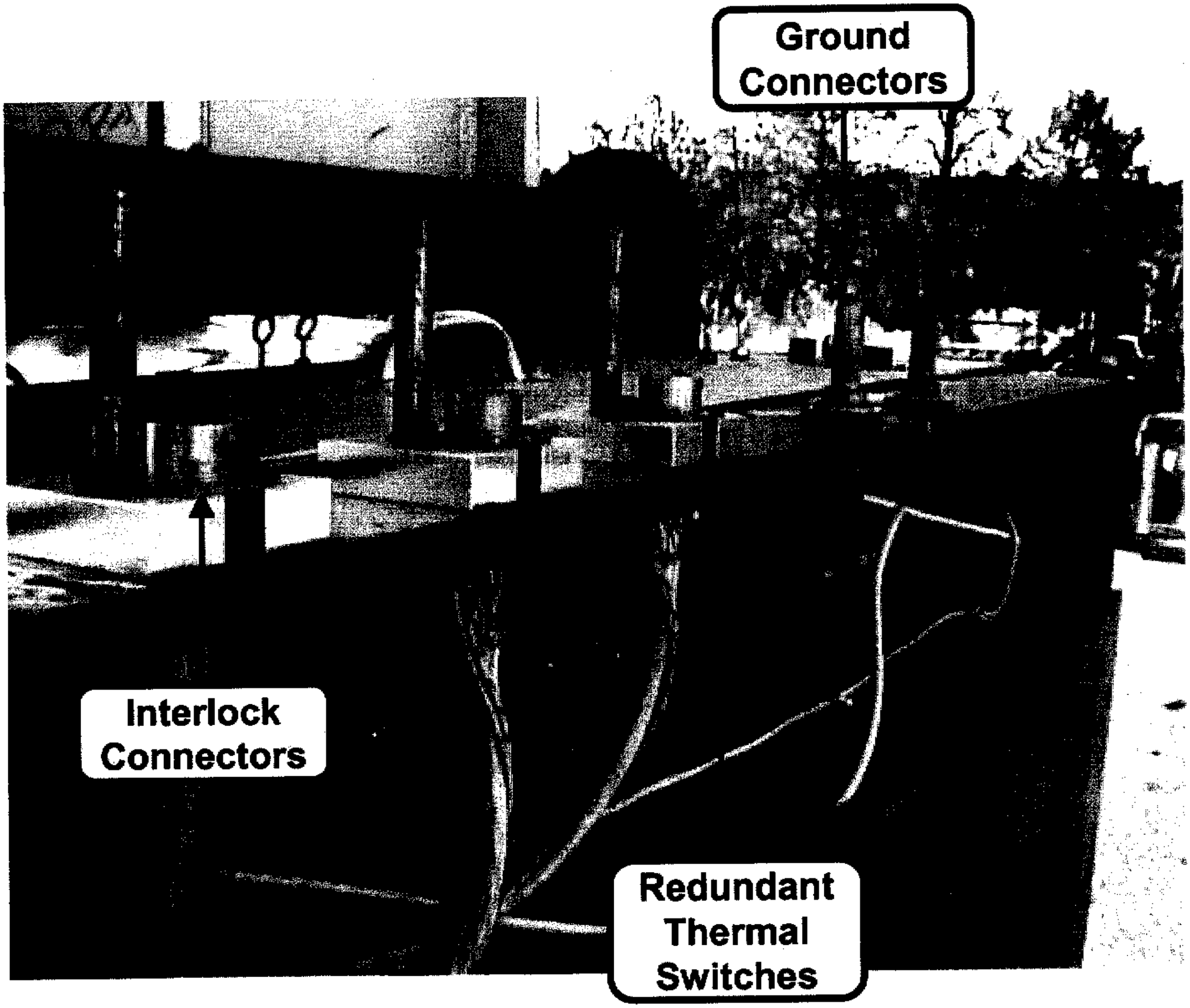
Area A Target Cell Quadrapole Triplet



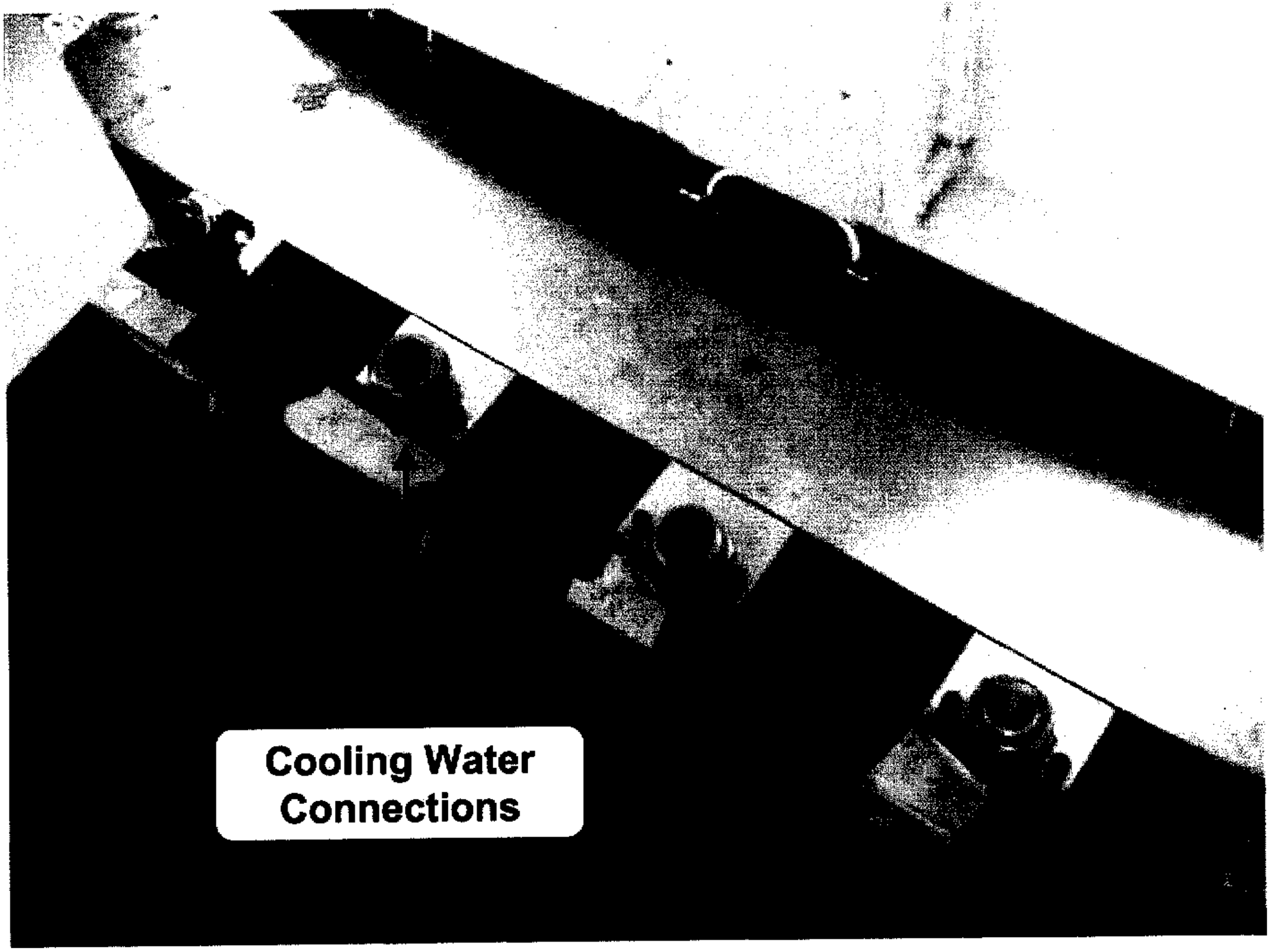
Area A Target Cell Quadrapole Triplet



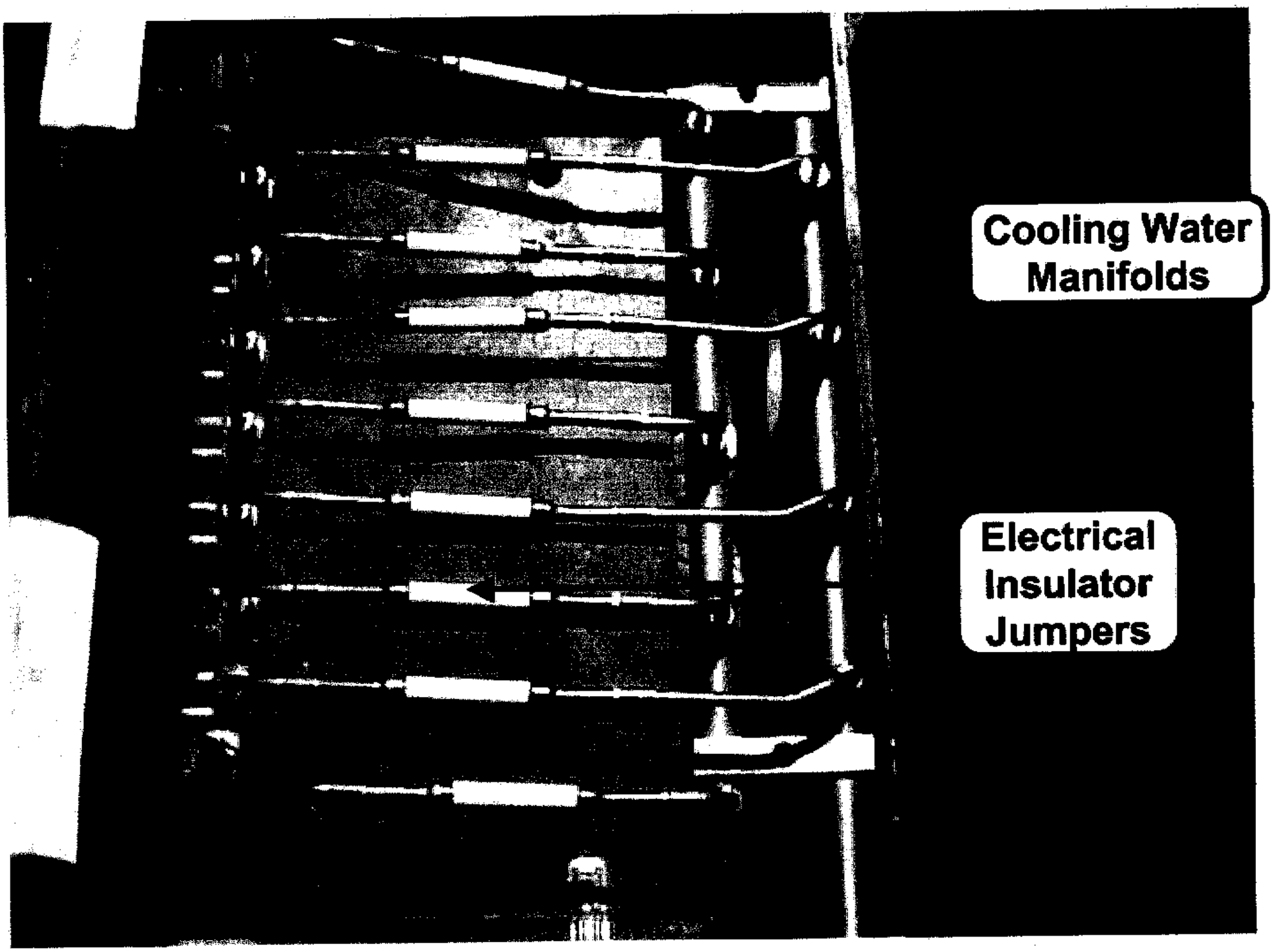
Area A Target Cell Quadrapole Triplet



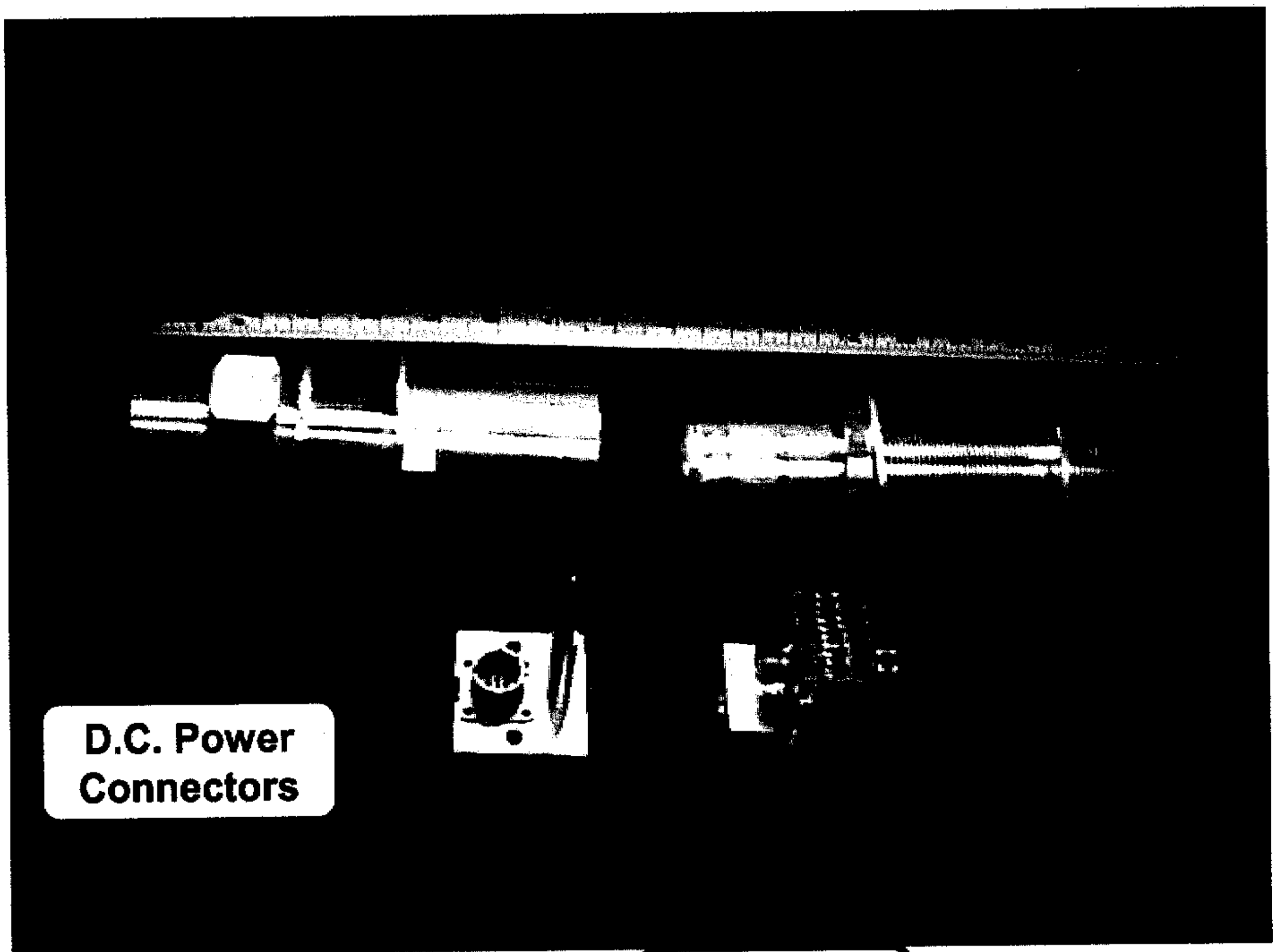
Area A Target Cell Quadrapole Triplet



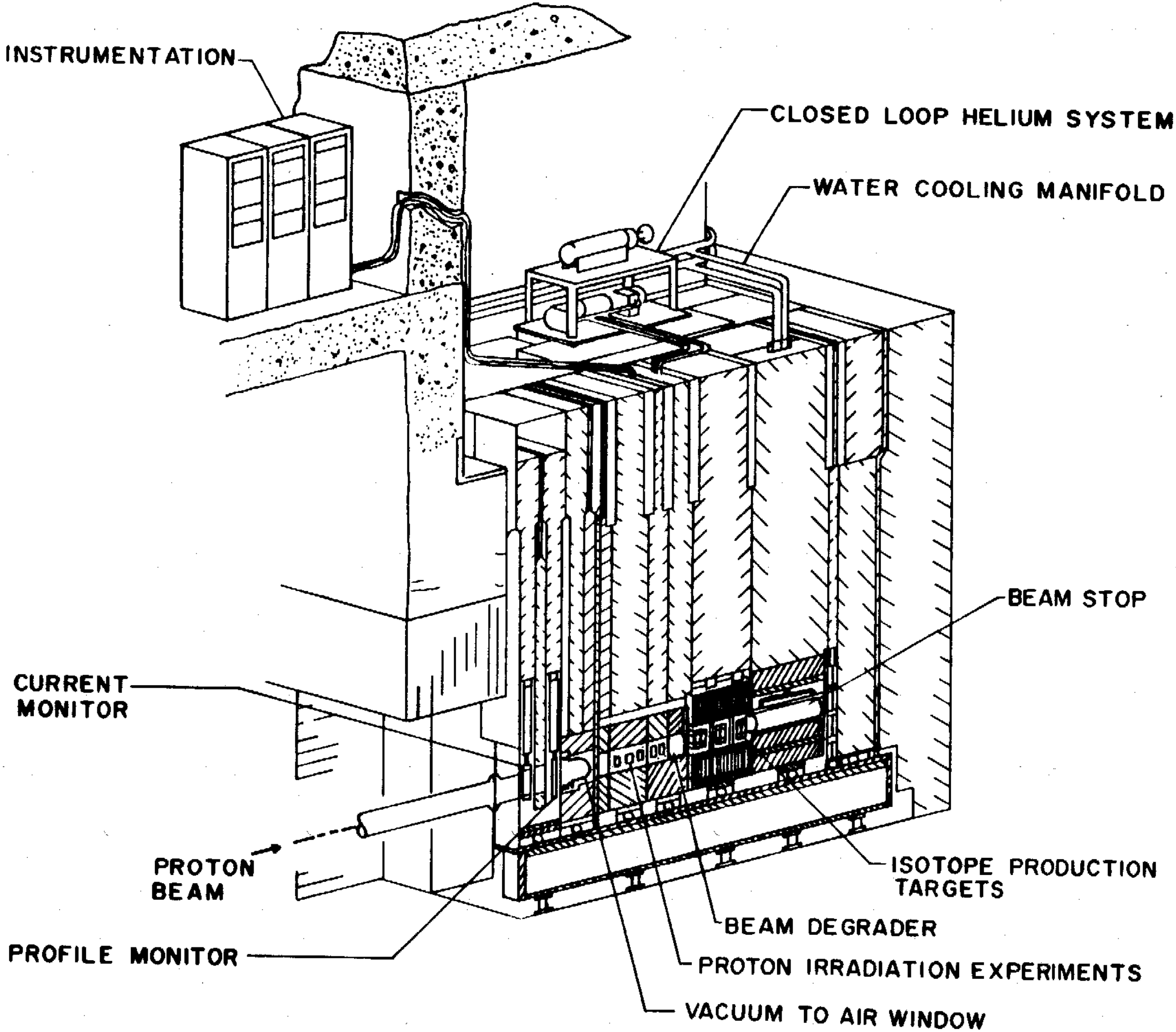
Area A Target Cell Quadrapole Triplet



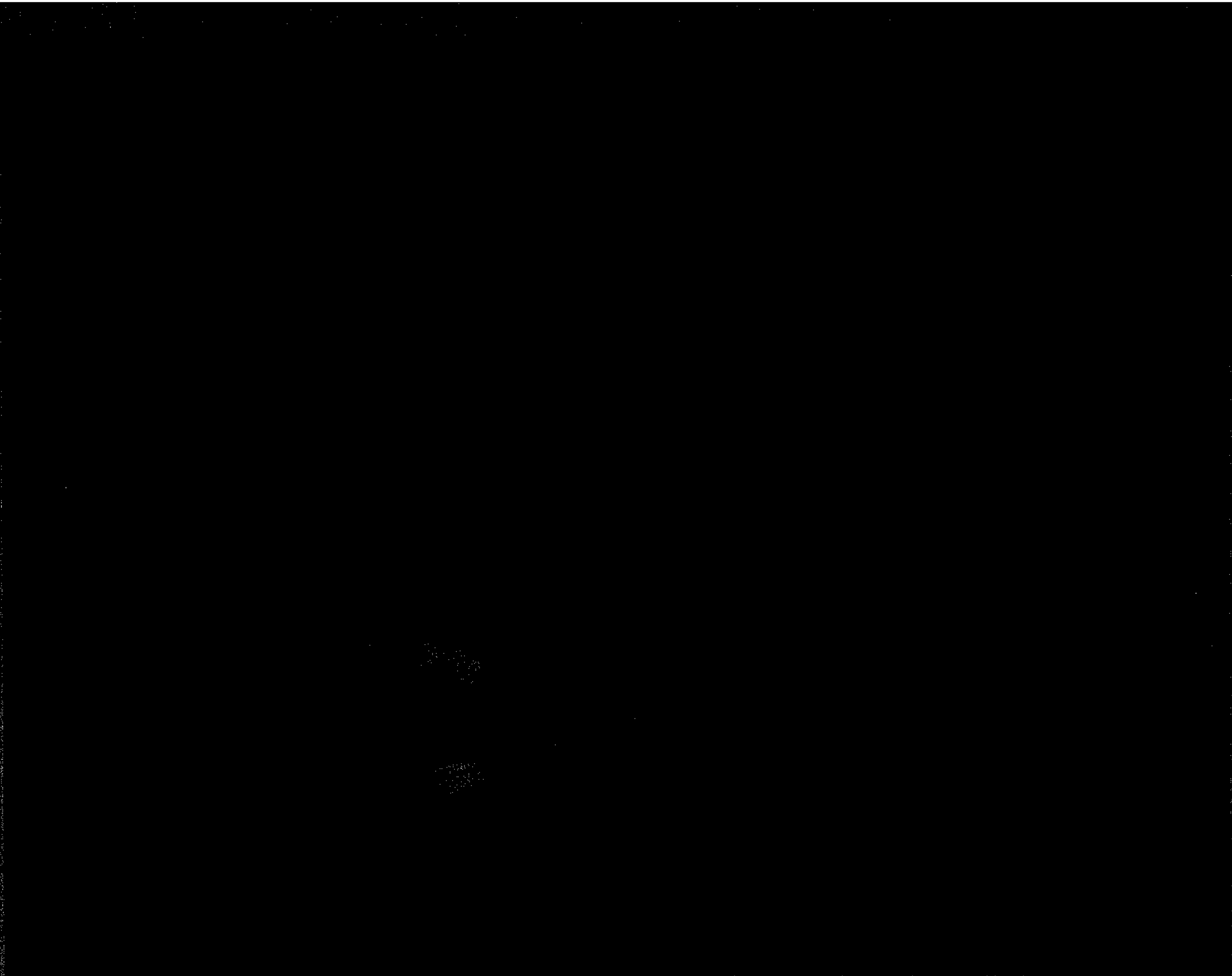
AREA A TARGET CELL QUADRAPOLE TRIPLET ELECTRICAL CONNECTORS



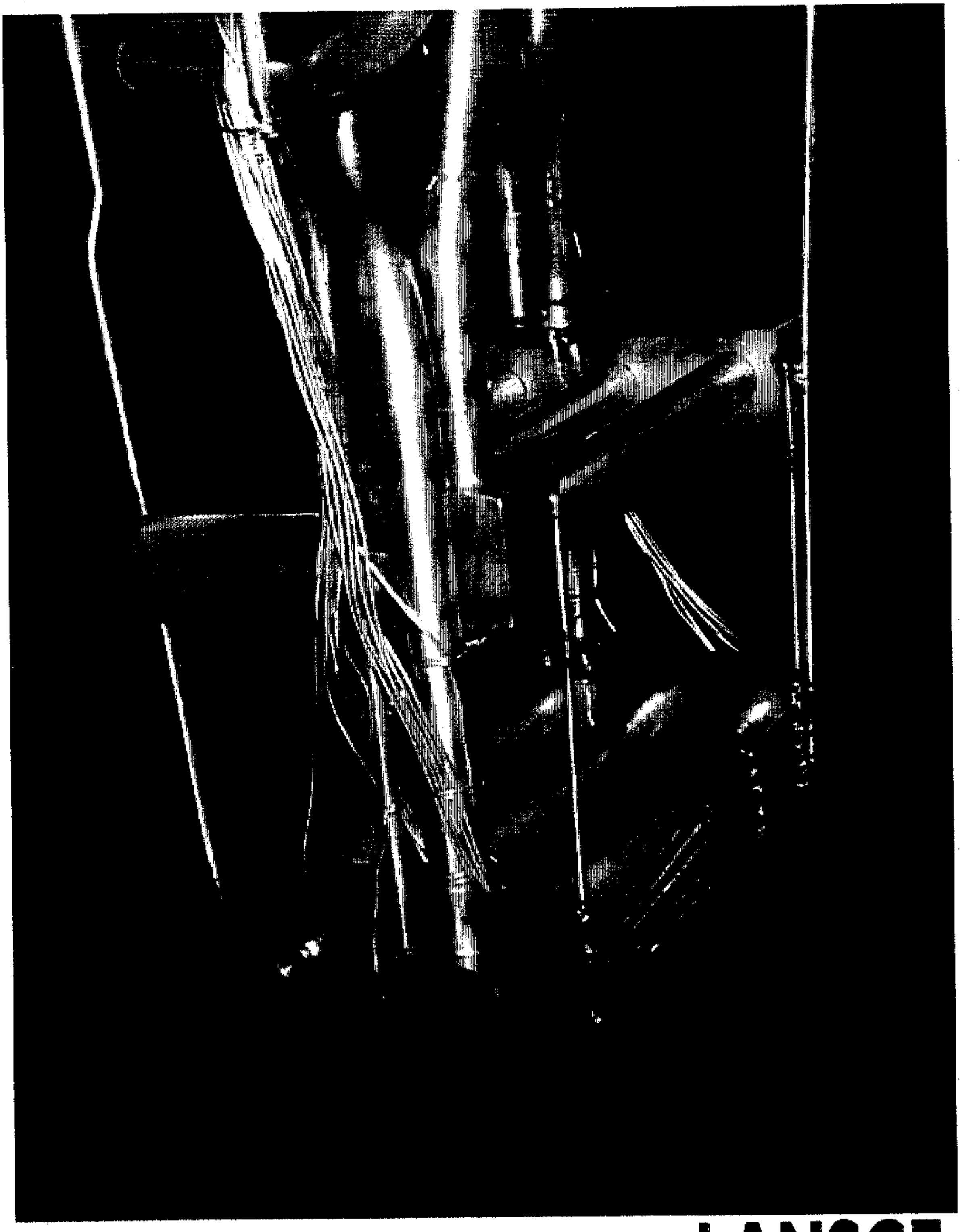
Interlock
Connectors



TARGET STATION A-6



APT DECAY HEAT EXPERIMENT MODULE



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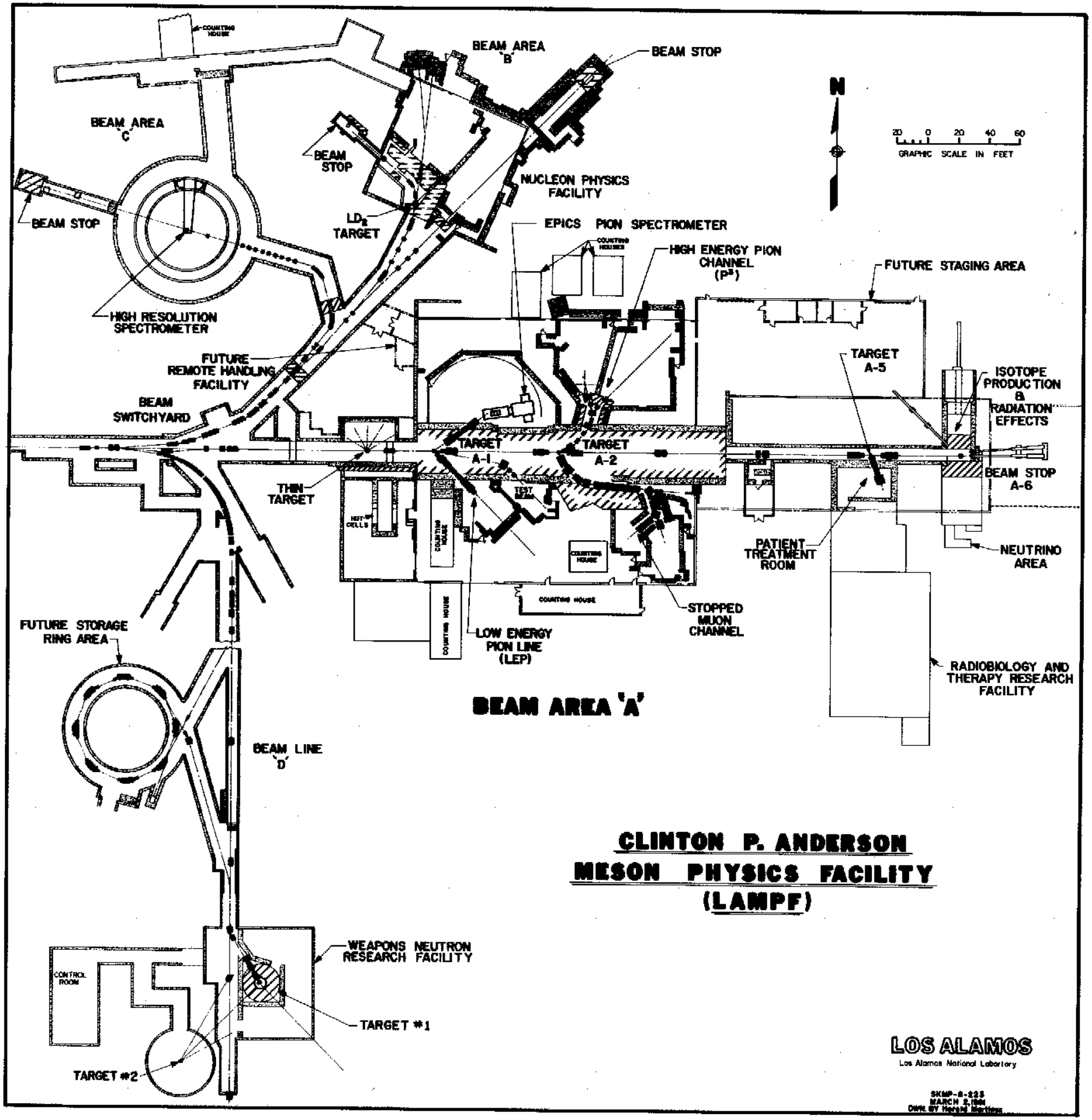
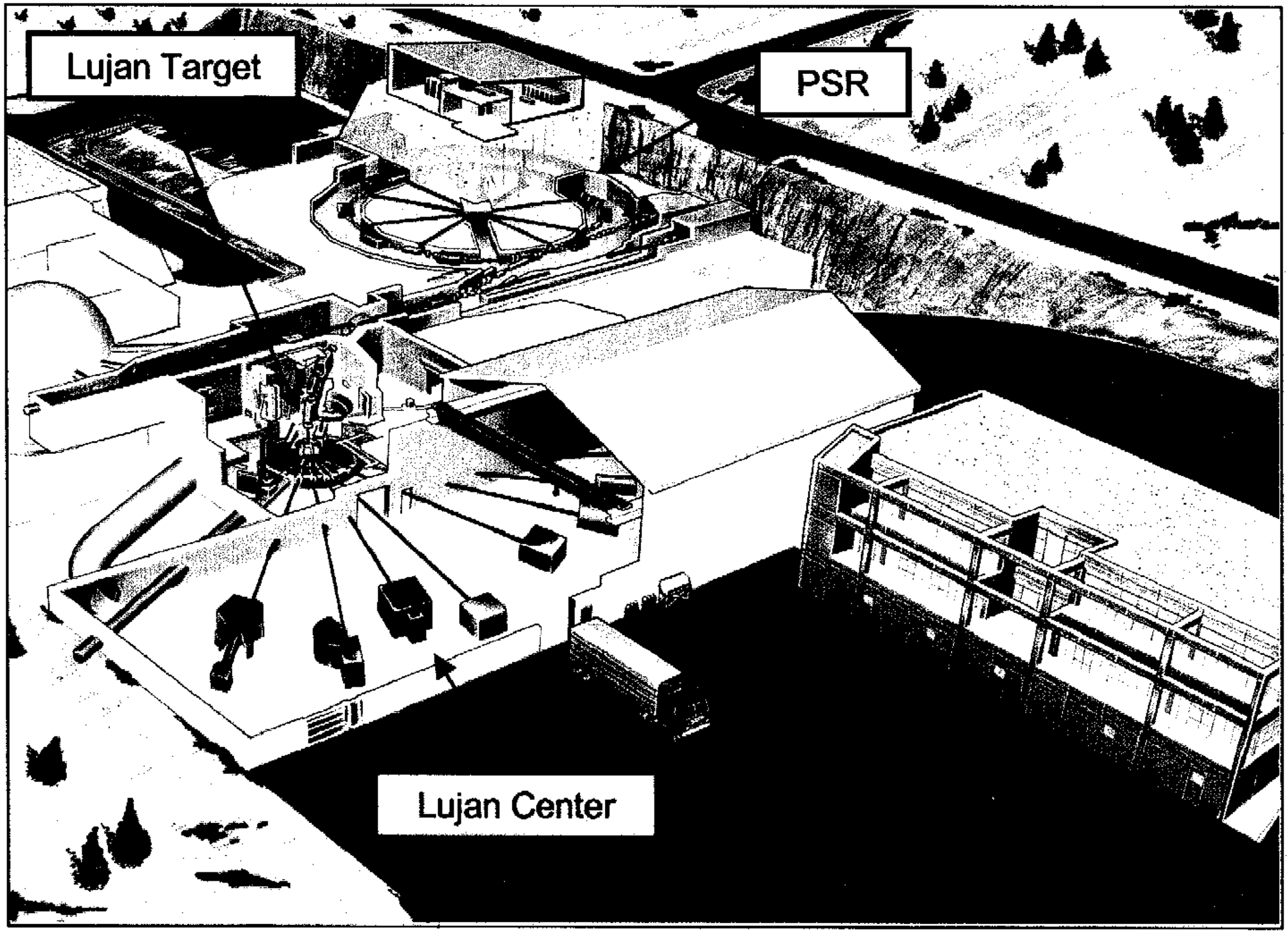
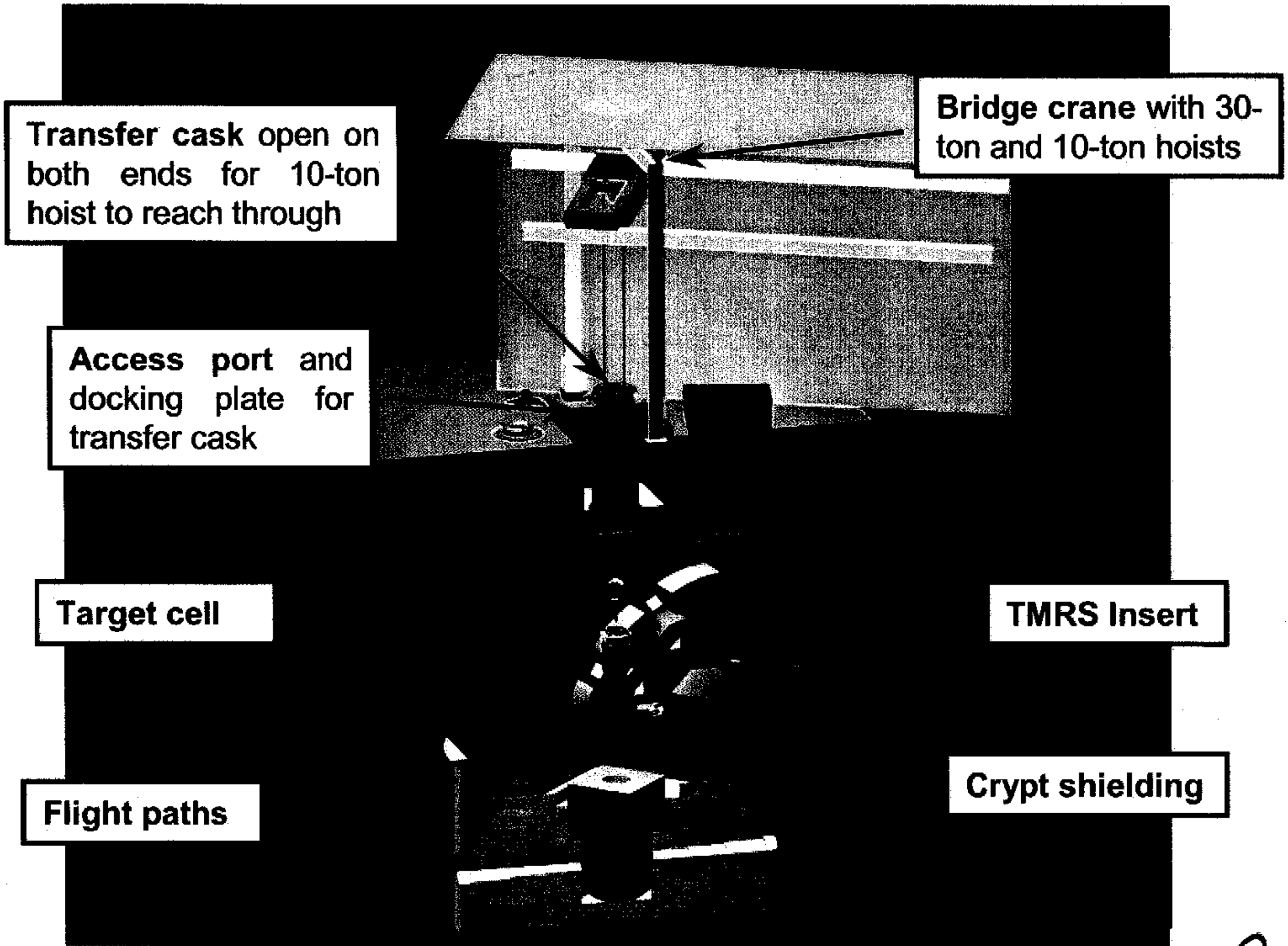

BEAM AREA 'B'
BEAM STOP
BEAM AREA 'C'
BEAM STOP
BEAM STOP
N
GRAPHIC SCALE IN FEET
20 0 20 40 60
NUCLEON PHYSICS FACILITY
LD$_2$ TARGET
EPICS PION SPECTROMETER
HIGH ENERGY PION CHANNEL (P^3)
FUTURE STAGING AREA
HIGH RESOLUTION SPECTROMETER
FUTURE REMOTE HANDLING FACILITY
BEAM SWITCHYARD
TARGET A-5
ISOTOPE PRODUCTION & RADIATION EFFECTS
TARGET A-1
TARGET A-2
BEAM STOP A-6
THIN TARGET
PATIENT TREATMENT ROOM
NEUTRINO AREA
STOPPED MUON CHANNEL
LOW ENERGY PION LINE (LEP)
COUNTING HOUSE
FUTURE STORAGE RING AREA
RADIOBIOLOGY AND THERAPY RESEARCH FACILITY
BEAM AREA 'A'
BEAM LINE 'D'
CLINTON P. ANDERSON
MESON PHYSICS FACILITY
(LAMPF)
WEAPONS NEUTRON RESEARCH FACILITY
CONTROL ROOM
TARGET #1
TARGET #2
LOS ALAMOS
Los Alamos National Labortory

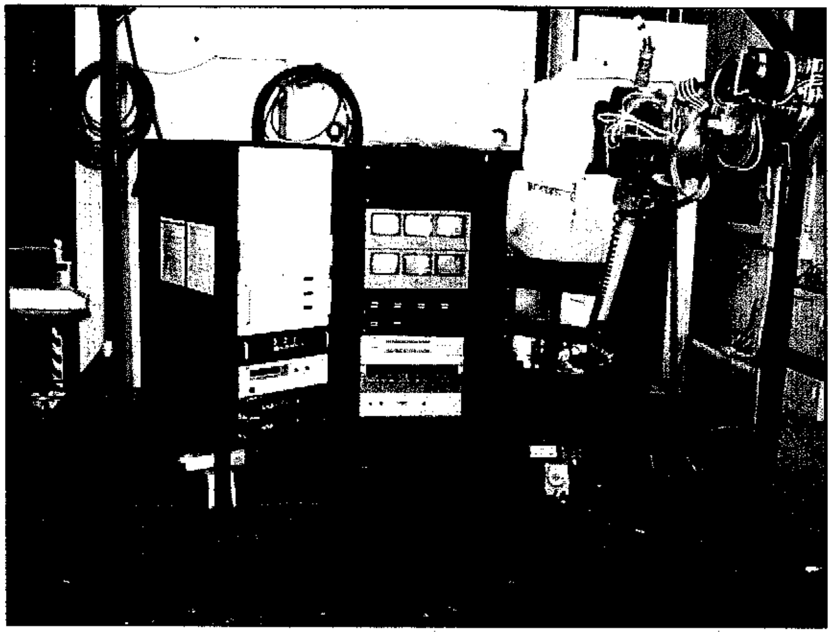
Overview of PSR and Lujan Center



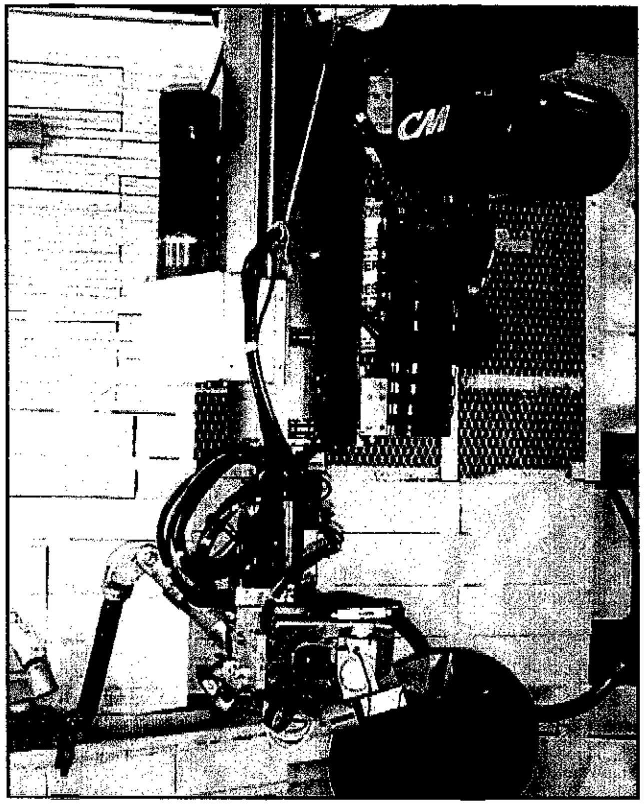
Lujan Target Removal Operation



Remote Handling Equipment for Lujan Target

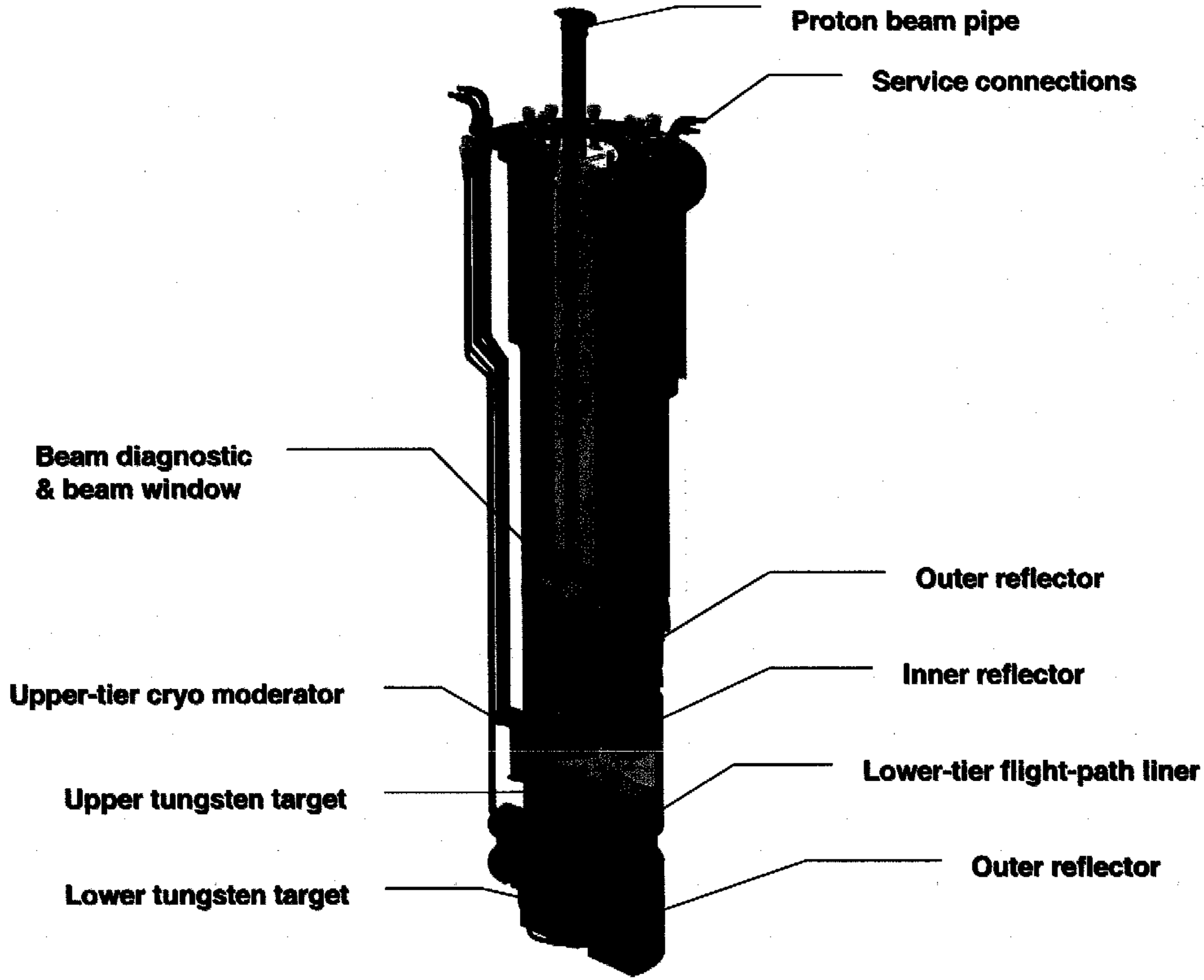


Master control station for crane, cameras, and master manipulator arm located in service aisle



Slave manipulator arm attached to 5-ton bridge crane inside cell

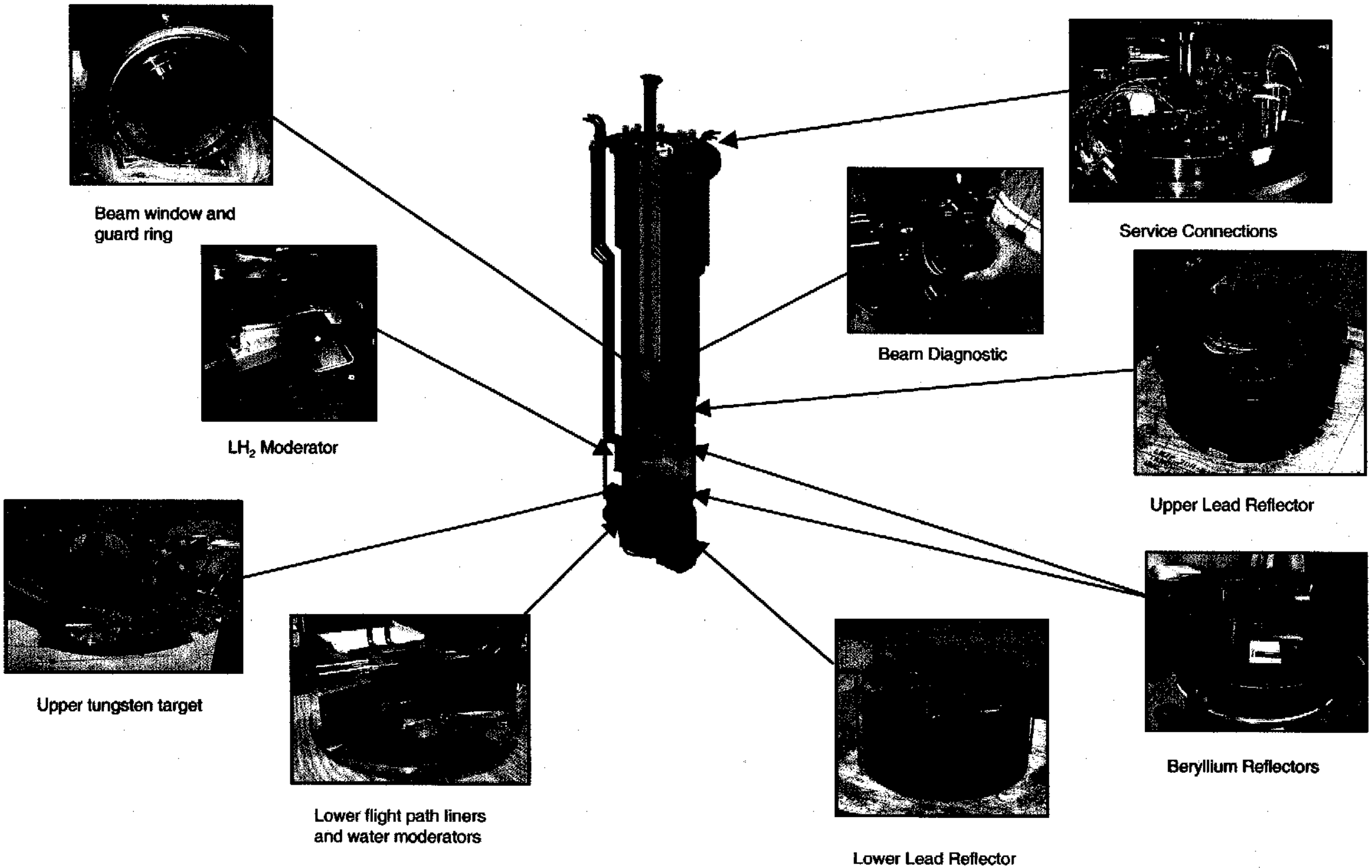
TMRS Insert



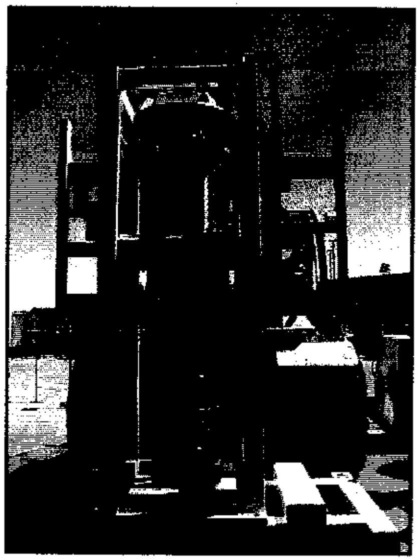
Proton beam pipe
Service connections
Beam diagnostic & beam window
Outer reflector
Inner reflector
Upper-tier cryo moderator
Lower-tier flight-path liner
Upper tungsten target
Outer reflector
Lower tungsten target

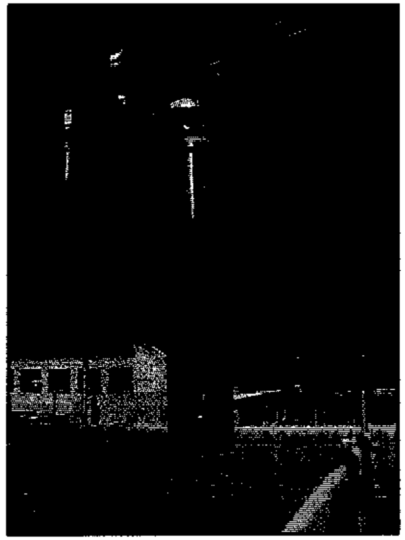
LANSCE SHORT-PULSE SPALLATION SOURCE

Target-Moderator-Reflector System Insert

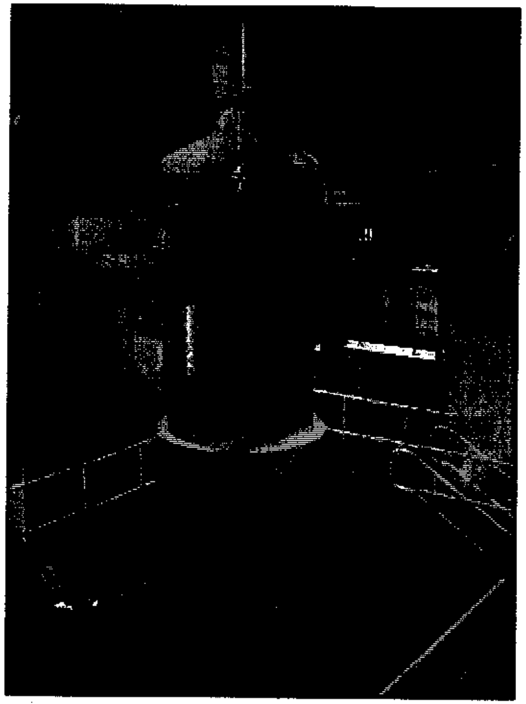


TMRS Insert Installation
26 June 1998

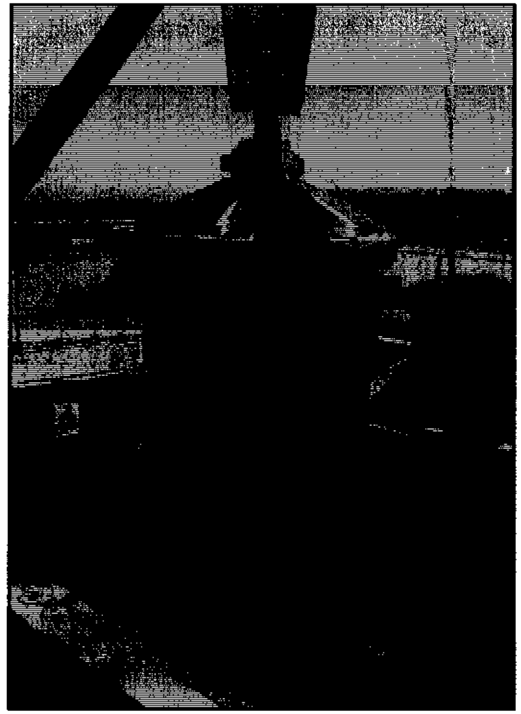




Target Transfer Cask



Transfer cask on Area A assembly stand



Transfer cask located on roof access port during dry run

SUMMARY OF CONSIDERATIONS FOR DEALING WITH HIGH POWER BEAM INTERACTION AREAS

- In addition to a component's basic design, its installation, alignment, hookups, repair, removal, and disposal should be addressed from the beginning. Details are very important; even "the little things" need to be engineered.
- A fundamental understanding of components and their support systems is very important; leave "nothing" to chance.
- "Overdesigned," simple designs work; don't be too "clever."
- Quality of designs and assembled components is very important; there is "no forgiveness" once things become radioactive.
- Chances are a design won't be "right" the first time; take that into account when designing components and "laying-out" beam lines.
- The environment in which components exist during beam delivery is very harsh; this includes the atmosphere and cooling water in addition to heat, radiation, and beam on/off cycles.
- Following irradiation, if the radionuclide inventory of beam line components (usually items struck by the beam) exceeds published values (per DOE-STD-1027-92), nuclear facility safety requirements may become pertinent. This introduces a high level of formality into component design, procurement, maintenance, configuration management, operation, surveillances, etc.